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THE HAWAIIAN PLANTERS' RECORD

VOL. XXXIV

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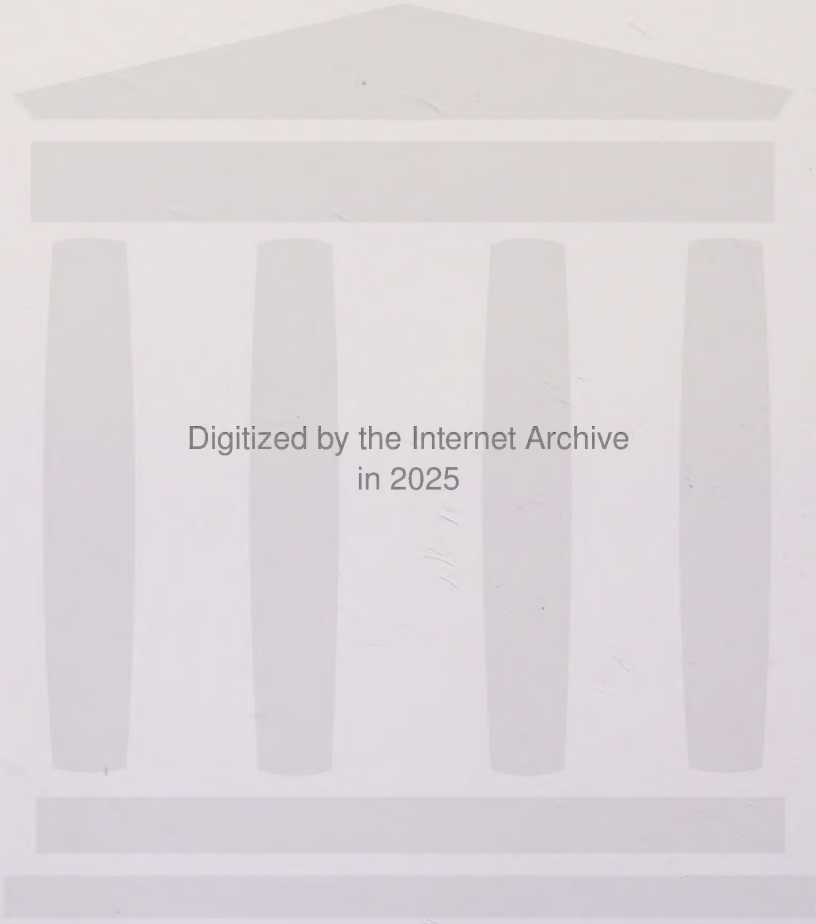

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THE HAWAIIAN PLANTERS' RECORD

Volume XXXIV. JANUARY, 1930 Number 1

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

In This Issue:

Gumming Disease of Sugar Cane:

Gumming disease is considered one of the oldest maladies affecting sugar cane. Through the importation of diseased cuttings the malady has spread from one cane country to another, often resulting in serious losses. It now occurs in nine different sugar cane countries.

In this issue the following points regarding the disease are presented: the geographic distribution and history, the description of the disease and of the symptoms used in diagnosis, the tissues affected, description of the causal organism and its transmission, and methods used in controlling the disease.

To date the most effective control has been secured through the substitution of resistant varieties. In areas affected with gumming disease new cane varieties should be tested as soon as possible in order to establish their resistance to gumming disease.

Eye Spot and Brown Stripe:

The results of several years' observations on eye spot resistance on a large number of cane varieties are presented in tabular form. Those canes of agricultural promise which appear in Groups I or II should be preferred for trials or spreading in eye spot areas to the canes appearing in Groups III or IV. No mention is made in this paper of the agricultural qualities of the canes in question.

Those varieties listed which are preceded by an asterisk, have, at one or more times, been found susceptible to mosaic disease.

The number of observations made on each variety is noted. Conditions in the fields or plots, where the growing canes have been observed, have been made favorable by fertilization for the production of eye spot epidemics. In all cases H 109 cane has been used as the standard for comparative purposes.

In Part II of this paper are recorded observations on a limited number of cane varieties in reference to their relative resistance and susceptibility to brown stripe disease.

It will be observed that, in many cases, those varieties which have shown marked resistance to eye spot disease have a very marked susceptibility to brown stripe disease. Due to the relatively recent determination of the latter disease, a lesser number of observations have been made on a smaller number of cane varieties. Further observations will be made and more data presented on this problem at a later date.

Notes on Pythium Root Rot:

It has been shown in recent papers that nitrogeneous soil amendments greatly increase *Pythium* rot of Lahaina cane roots. The continued vigorous root growth of H 109 cane in parallel experiments has been reported as of practical significance. In this issue further observations on certain soil factors which influence the activity of the *Pythium* fungus and determine the degree of rot are recounted.

Experiments showed that the roots of H 109 break down under *Pythium* attack if the soil is heavily amended with stable manure. With amendments of 50 to 75 per cent by volume of stable manure the effect on H 109 roots is comparable with the effect of 5 to 10 per cent amendments on Lahaina roots. The high concentration of nitrogeneous material required to induce susceptibility of H 109 roots is not likely to occur in the field, or to be of long duration if accidentally reached in restricted areas. It was noticed that after a time, apparently when the concentration had become reduced, sound root growth was resumed. Further studies are required to determine the relation of lack of balance of nutrients to root rot.

The effect of molashcake in increasing *Pythium* rot has been mentioned. It was found in the present studies that molasses and press cake, the chief nutrient materials in molashcake, stimulated growth and were active in producing conditions favorable for root rot of Lahaina. Bagasse had the opposite effect, growth was depressed and no root rot occurred. This observation suggests a possibly useful role for bagasse as a soil amendment in suitable combinations with molasses to retard reactions, extend beneficial effects and check harmful tendencies.

Experiments are cited to show that nitrogeneous materials do not in themselves cause root collapse. It is inferred that they act indirectly by stimulating root growth to the point where it becomes susceptible to *Pythium* attack.

Some of the modifications of a healthy soil necessary to bring on root rot having been determined, an experiment to demonstrate the reverse effect was conducted. Soil from Olaa which is notoriously "sick" for Lahaina cane, was diluted progressively with "healthy" Makiki soil, and the effect on Lahaina roots observed. Improvement in root condition was marked when the sick soil constituted one-half or less of the mixture. Rotting of the roots was negligible where the sick soil was but 20 per cent of the mixture.

In view of the present and earlier experiments it seems obvious that *Pythium* root rot varies in severity with the concentration of stimulative nutrients in the soil.

Iron Sulphate Spray for Coral Chlorosis:

In a test conducted cooperatively with Ewa Plantation Company, using a 5 per cent solution of iron sulphate spray on short ratoons, a gain of nearly 35 per cent was obtained in favor of the spray. This gain represented 15.88 tons of cane and 1.8 tons of sugar.

Iron sulphate spray can be applied to correct coral chlorosis on a field scale at a very low cost.

A Study of Sugar Cane Roots:

A study is made of the development of roots of the sugar cane plant from the root primordia, which occur as "root dots" on the "root bands" of the stems. A number of varieties are compared as to the number and per cent of root primordia developing into seed-piece roots and as to the number of shoot roots developing at intervals of 5, 10, 15, 25 and 50 days after the seed piece is planted. The number of roots primordia and, therefore, the possible number of seed piece roots per node varies greatly for the varieties studied.

At the end of a 5-day period, for example, on ten H 109 seed pieces, 139 root primordia, or 3.6 per cent of the total possible, had developed into seed-piece roots, while on the same number of Yellow Caledonia seed pieces, 2,871 root primordia, or 64.6 per cent, had developed into seed-piece roots. The percentage of root primordia developing into seed-piece roots on seed pieces 50 days after planting is very little higher, if any, than for seed pieces from 5 to 25 days after planting. A certain number of root primordia are held in reserve and develop only in case of need. The total per cent of root primordia developing into seed-piece roots was less for seed pieces left in the ground undisturbed for 50 days than for seed pieces removed from the soil, the developing roots cut off, and the seed pieces replanted at intervals of 5, 10, 15 and 25 days for the same period.

No correlation exists between the number of root primordia of different varieties and the development of the shoots from the buds, which does not preclude a correlation between development of shoots (stand of cane) and the number of root primordia for a given variety.

Shoot roots developed from the root primordia of the bud and pushed out from between the bud scales as early as 5 days after the seed pieces were planted.

For the varieties studied the number of shoot roots developing on shoots from seed pieces undisturbed for 50 days *exceeded* the average of the number developing on shoots from seed pieces disturbed at intervals of 5, 10, 15 and 25 days. This is in contrast with the data for the seed-piece roots, for, without exception for the same varieties, the percentage of seed-piece roots developing on seed pieces undisturbed for 50 days *was less* than the average of those developing on seed pieces disturbed at intervals of 5, 10, 15 and 25 days.

These facts may help interpret the significance of various types of root injury and may have a practical application to the practice of off-barring and sub-soiling. *The "pruning" of the seed-piece roots stimulated into development root primordia of the seed pieces which under normal conditions would have been held in reserve.*

The "pruning" of the shoot roots resulted in fewer roots being developed from the shoots.

Molasses as a Fertilizer:

During the recent low price of molasses considerable interest was manifested in its value as fertilizer. It had been formerly believed that molasses was injurious toward cane growth. During this period of low price some few plantations made field applications of molasses which gave notable improvement in cane growth. In this paper some effects of molasses fertilization have been studied which lead us to believe that molasses will react, much like a fallow toward an infertile soil. Soil conditions in field showing both injury and benefit have been studied. Injury occurs in poorly drained soils or soils high in "active" aluminum. Benefit is obtained from better soil aeration and a rejuvenation of the biological soil flora.

Pahala Blight:

An article appearing in this number presents data upon the Pahala blight, namely, the ash, iron and manganese content of leaves as related to chlorosis and as affected by sulphur fertilization.

Oriental Rice Borers and Their Parasites:

This paper is a short report on the work done in the Orient: Japan, Formosa, and China, in the year 1928, in searching for parasites of the rice borer. Eighteen different species of parasites or predators were found more or less effectively controlling the rice borer in the Orient. About ten species of these parasites were successfully sent or brought to Honolulu, and arrived alive. They were either turned loose to shift for themselves in the rice fields, or were raised through several generations in the laboratory and then released.

Three species of these parasites have been recovered in the field, and their establishment thus verified. They are: the egg-parasite *Trichogramma japonicum* Ashm., and two larval parasites, *Amyosoma chilonis* Vier., and *Dioctes chilonis* Cushm. It is possible that some of the other species of parasites have become established, but are still too scarce to be recovered.

All of this work on borer parasites is of interest to sugar planters for the reason that some of the rice borers of the Orient attack sugar cane as well as rice, though the one now occurring in Hawaii does not attack cane.

Cane Breeding in Formosa:

Formosa, like Hawaii, is near the climatic limit for cane growing, and especially for cane breeding. The fertility of the tassels of a given variety is much lower in the cooler regions than in more tropical countries, and many varieties do not

tassel at all. Formosa is fortunate, however, in being able to carry on much of its breeding work at a Japanese-owned plantation in Java, the tassels being shipped when ripe to Formosa for planting.

The possibilities in cane breeding are fully appreciated in Formosa. About 300,000 seedlings have been germinated since the work was started in 1914 and at present about 50,000 seedlings are being grown each year. Special attention is being given to seedlings of P. O. J. 2364, P. O. J. 2725, and other parents which have been used with success in Java.

Cane Varieties in Formosa:

In the early period of the Formosan industry canes of the Uba type were almost exclusively grown. With the advent of Japanese capital, modern mills and improved cultural methods, Striped Mexican imported from Hawaii became the principal variety. It was, in turn, replaced by P. O. J. seedlings of Chunnee blood, especially P. O. J. 36, P. O. J. 105 and P. O. J. 161. During the last three years these have rapidly given way to the newer P. O. J. seedlings of Kassoer derivation, especially P. O. J. 2725 and P. O. J. 2714, which now occupy most of the 290,000 acres in cane.

Considerable interest is being taken in P. O. J. 2878, but whether it will be able to outyield the present varieties is still questionable.

Asphaltic Sealing of Reservoirs:

In this issue a paper is presented which caries a detailed discussion of the technic followed in the recently developed asphaltic sealing of earth reservoirs.

Descriptions and photographs of the California system of oil treatment of reservoirs are included.

Lippincott and Standard Oil Company specifications are given for the impregnation and hardening of an asphaltic soil treatment and also for preparing and applying a mastic ditch lining.

The Parshall Measuring Flume

The Improved Venturi Flume is hereafter to be known as the Parshall Measuring Flume, according to J. C. Stevens, secretary of the Special Committee on Irrigation Hydraulics, who writes as follows:

> This committee has felt for some time that the name, "Improved Venturi Flume," as developed by R. L. Parshall, Associate Member, American Society of Civil Engineers, for measuring irrigation water in the West, is a misnomer. We also felt that the name could well be changed to in some way give Mr. Parshall credit for this development. We took this matter up with the Executive Committee of the Irrigation Division, and also with S. H. McCrory, Member, American Society of Civil En-

gineers; Professor W. W. McLaughlin, Associate Chief, Division of Agricultural Engineering, U. S. Department of Agriculture; and C. A. Lory, President, Colorado Agricultural College, who recognized the desirability of a change of name. Accordingly, at its last meeting this committee unanimously adopted a resolution proposing to change the name from "Improved Venturi Flume" to "Parshall Measuring Flume."

Formosan Views

A Formosan farmstead.

P. O. J. 2878 under trial in Formosa.

Formosan field laborers.

Formosa: A harvest scene, P. O. J. 161, formerly the leading variety.

A farmhouse, Formosa.

Cane Varieties in Formosa

By A. J. Mangelsdorf

It should be mentioned at the outset that there is very little ratooning in Formosa. The greater part of the crop is plant cane. One reason for this is that the cost of field operations, such as plowing and planting is low, due to the relatively low cost of labor. Plant yields have been found to exceed ratoon yields by a sufficient margin to more than offset the cost of planting operations.

It is likely that the pronounced dry season in the southern two-thirds of the island plays an important part in the rather marked decline in the yield of ratoons as compared with plant. After a field is harvested, it may lie for two or three months, baking in the sun until the rains begin and the roots receive enough moisture to start off the ratoons.

In the northern part of the island there is an abundant supply of irrigation water, and whereas in the south only the rice is irrigated, in the north there is enough water for both cane and rice. Here, P.O.J. 2714 is the principal cane, and one ratoon crop is the rule.

P. O. J. 2725 in Formosa. This is the leading variety at present. It is drought resistant and has good juices.

P.O.J. 2725 continues as the leading variety in Formosa. It now occupies about half of the total area. It is preferred especially in the south, under unirrigated conditions, where, as has been mentioned, the winters are very dry. Much of the cane which we saw had had almost no moisture for three months or more,

nor was it likely to receive any until around June, during which month the summer rains usually start. Its ability to withstand drought might make this cane a useful one for the Kohala district. It tassels very heavily, as in Hawaii, but probably because of the dry, cool winters it undergoes very little deterioration before April, by which time harvesting is practically finished. P.O.J. 2725 has been found in Formosa to be extremely resistant to mosaic.

P.O.J. 2714, as has been mentioned, is the leading variety in the north, where the climate is cooler and the moisture more abundant. It now occupies about one-fourth of the total cane area of Formosa. The fact that the only extensive ratooning practiced in Formosa is with this variety would seem to indicate that it must be a fairly satisfactory ratooner, a point of considerable interest to us.

P.O.J. 2727 has increased slowly during the past two or three years and now occupies about 7 per cent of the total cane area. It does not tassel as heavily as P.O.J. 2725. However, Mr. Ebi, agriculturist for the large Taiwan Sugar Company, is of the opinion that neither P.O.J. 2714 nor 2727 hold over as well as 2725.

P.O.J. 161, 105 and 36, at one time the three most important varieties in Formosa, continue to decline in acreage, and will soon be entirely replaced by the newer P.O.J.'s. The three together still occupy about 15 per cent of the total cane area.

The fact that P.O.J. 36 is being replaced in Formosa need not necessarily discourage its spreading in Hawaii. Conditions in the two countries differ in a great many respects. Formosa has no weed problem, it does little ratooning, its winters are dry while its summers are wet, and, finally, it does not grow cane at high elevations. With the rather marked differences in conditions it would not be particularly surprising to see a cane which had been replaced in the one country succeeding in the other.

Of the Formosan seedlings only F. 4 and F. 19 have been planted on a large scale. Both reached a peak last year, when F. 4 occupied 7000 acres, and F. 19 about 17,000 acres. Their acreage this year has declined somewhat. Evidently they are being replaced by P.O.J. 2725.

Badila is grown throughout the island as a chewing cane. Its total area is listed at over a thousand acres. Chewing cane is sold in every village by street venders and in the markets it is prepared for sale by carefully trimming away the eyes and washing and polishing the stalks, after which it is cut up into lengths of about eighteen inches each. Some is shipped to ports in China. We saw in Amoy Badila which had evidently come from Formosa.

We saw a number of P.O.J. 2878 nurseries during our stay in Formosa. This cane is being spread rapidly, although figures as to its yielding ability, in comparison with the present varieties, are not available. There is some difference of opinion as to whether it will replace P.O.J. 2725. The majority of those who were willing to venture an opinion seem to feel that it gives promise of outyielding the varieties now being grown. It is said to carry over well and to make a very rapid growth during the hot, moist summer months.

It is evident that Formosa is preparing to give P.O.J. 2878 a thorough trial.

Cane Breeding in Formosa

By A. J. Mangelsdorf

The experimental work in connection with the Formosan sugar industry is carried on mainly at the Shinka Station. This station is located at Shinka near Taiwan, in the south-central part of the island.

The Shinka Station is a branch of the Central Research Institute, a government organization, the agricultural division of which performs much the same functions as our U. S. Department of Agriculture.

There are forty-eight factories on the island. Many of these employ their own agriculturists who also carry on experimental work in connection with varieties, fertilizers and cultural practices.

The Shinka Station has at its disposal 375 acres of land. A three-year rotation is followed. Each year about 100 acres are planted to cane, with the remainder in rice, sweet potatoes and leguminous crops, especially *Sesbania* and *Mucuna glauca*. The leguminous crops are grown for turning under as green manure. This is a general practice and is believed to be more economical than a system of continuous cropping, which would necessitate larger purchases of commercial fertilizers from abroad.

Newly potted seedlings at the Sugar Experiment Station, Shinka, Formosa. From 30,000 to 70,000 are grown each year. They are subjected to three or four years of testing by the Station. The poorer ones are eliminated and only the best are given to the plantations for final trials.

The cane breeding at Shinka Station is carried on under the supervision of Dr. Kaneko, the director. Associated with him in this work are Dr. Sakamoto and his assistant, Dr. Hisatomi.

The first crosses were made in 1914, since which time a total of almost 300,000 seedlings have been grown. During the past few years the number has ranged from 30,000 to 70,000 yearly.

Nursery Procedure

The methods followed in germinating the seedlings are much the same as those practiced in Hawaii. The Shinka Station, however, lacks the greenhouses and heated tables which have been so helpful in Hawaii in reducing mortality in the early stages.

The fuzz is sown in flats, which are placed on unheated tables covered with glass hot-bed sash. When they reach a height of several inches they are transplanted to rather large earthenware pots, each about 8 inches in diameter.

Crosses being made in Java for the Formosa Station. Each year a member of the Formosa Station staff goes to Gedaren in Java, a plantation owned by a Japanese syndicate, to make crosses. The fuzz is shipped to Formosa when ripe and is planted at the Shinka Station.

The growth of the seedlings in the nursery appears to be quite slow as compared with what we are accustomed to expect in Hawaii. This may be due to their rather cool winter season, or it may be that the potting soil used in the nursery is not entirely suitable.

Crossing Program

The climate in Formosa is rather unfavorable for crossing. Many varieties fail to tassel, and many which produce fertile pollen elsewhere are unfertile in Formosa.

To escape this handicap the station began in 1922 to make crosses at Gedaren, a Japanese-owned plantation in Java, where conditions are very favorable for crossing work.

Each year a member of the Shinka staff goes to Java to supervise the crossing at Gedaren. Dr. Sakamoto was in Java for this purpose during 1929.

When ripe, the crossed tassels are sent to Formosa for germination. In view of the presence in Java of a number of serious diseases this policy might seem to be rather a hazardous one. Great care is exercised, however, in the fumigating and disinfecting of the imported tassels and the Station staff feel that very little hazard is involved. Dr. Miyake, the pathologist, told us that in the seven years during which fuzz has been imported from Java he has not found a single instance of disease being introduced with the fuzz.

Crossing Method

The sulphurous acid method is not used in Formosa. The crosses are made in the field. The female tassel is bagged with a large cloth bag about 20 inches in diameter and 40 inches long. The bag is supported by a bamboo pole. The male tassel is cut, placed in a bamboo vase containing water and tied in position within the bag in contact with the female. The fact that the male tassel is in water rather than in sulphurous acid solution necessitates replacing it with a fresh one each day during the blooming period of the female. This naturally requires considerable labor, but labor is abundant and cheap, which means that practices which are prohibitive in Hawaii may be entirely practicable here.

Selection of Seedlings

The selection procedure is similar to that practiced in Hawaii. The seedlings are planted in the field when they have reached a height of a foot or so. Each plant is given about two and one-half feet of space in the row, with about four feet between rows.

The first selection is made when the seedlings are a little less than a year old. About 10 per cent of them, on the average, are retained for a second trial. Ten seed pieces are cut from each of the selected seedlings. The seed is so spaced in planting that each seedling comes to occupy about fourteen feet of row in the second field trial. Every third row is a check row of P. O. J. 2725, the standard variety at Shinka.

The seedlings surviving the second selection are planted in blocks, each consisting of three 14-foot rows. Here again every third block is a check of P. O. J. 2725.

Subsequent selection is based on the harvesting results from checkerboard experiments. Each plot in these checkerboard tests contains about one-twentieth

acre. The tests are planted at the various factories as well as at the Shinka Station. Wherever possible ten replications of each seedling is the standard practice in these tests.

In addition to the seedlings grown by the Station, one of the factories, the Ako Sugar Mill at Heito is also growing about 10,000 seedlings a year.

All of the factories visited are keenly interested in testing the seedlings produced by the station. This interest extends even to the Chinese farmers, by whom most of the cane is grown under contract with the nearest mill.

The widespread interest in seedlings may be attributed to the success of certain of the seedlings which have been distributed during recent years, at first P. O. J. 105, 161 and 36, and more recently P. O. J. 2725 and 2714, all of which have had a part in the remarkable increase in yield of sugar per acre in Formosa.

Parent Material Used in Breeding

The history of the crossing work in Formosa falls into two distinct divisions. During the first period, which includes the years from 1914, when the work was begun, to 1923, P. O. J. seedlings with Chunnee blood were the leading varieties in Formosa and it was only natural that they should be the ones most extensively used in crosses.

The most important of these early P. O. J.'s of Chunnee derivation were P. O. J. 105, which was used both as a male and as a female in crosses, P. O. J. 143, 161, 920 and 1507, which were used as females, and P. O. J. 181 which was used very extensively as a male. These canes were crossed among each other and thus many of the combinations tried were brother-sister or half-brother-half-sister crosses. This fact may possibly account for the relatively small number of good seedlings obtained from combinations of this type. The seedlings also tended to have poor juices.

It is of interest to note that attempts were also made to use P. O. J. 36 in crossing. As in Hawaii and in other countries as well, it proved to be completely sterile.

The second period in the crossing work began when Formosa followed the lead of Java in the use of Kassoer blood. P. O. J. 2364 and 2725 are most extensively used. They have been crossed especially with P. O. J.'s and Formosan seedlings containing Chunnee blood, theoretically a promising line of attack.

Attention during the present crossing season is again being centered on crosses with canes of Kassoer derivation. There is also some interest in Uba crosses. E. K. 28, S. W. 111 and S. W. 499 are favored as males.

Many sister-brother crosses between P. O. J. 2725 and 2878 and also many mother-son crosses between P. O. J. 2364 and 2878 are also being tried this season. It remains to be seen whether seedlings resulting from such close matings as these will have the desired vigor.

Results of Breeding Work

Those seedlings which give promise of becoming commercial canes are given permanent F numbers. The F series includes at present 76 seedlings. Only two

of these have been planted on a large scale. F 4 is holding its own with about 7,000 acres, while F 19 has declined from its peak of 17,000 acres to around 9,000 acres. The acreage which it has lost has been taken up for the most part by P. O. J. 2725. Of the newer F seedlings 49, 58 and 63 are thought to be promising. The last mentioned seedling, however, appears to be quite susceptible to mosaic.

In conclusion, it may be said that the breeding work if continued on its present scale bids fair to keep the Formosan industry supplied with new seedlings which should be able to maintain, if not to exceed, the present yields. Selection is not so difficult as in Hawaii. There is very little ratooning in Formosa, by far the greater part of the acreage is plant cane. This is probably due largely to the fact that with cheap labor the cost of preparing and planting is low, and plant yields exceed ratoons by a sufficient margin to pay for the additional cost. The absence of ratooning naturally simplifies the selection work, since it is not necessary to wait for several years to determine whether a promising seedling will ratoon. Furthermore, since almost the entire area is replanted each year it can be quickly changed over to a new variety should a superior one be found. The variety census shows that as compared with Hawaii, for example, the acreages of the different varieties have changed with great rapidity. The further fact that conditions are fairly uniform in most of the cane growing area also simplifies the selection problem.

Pahala Blight
II

By W. T. McGeorge

It was experimentally shown by investigations conducted in 1924 and 1925 that sulphur, as a soil amendment, brought about a rapid recovery of cane afflicted with chlorosis at Hawaiian Agricultural Company. In about 2,000 acres on this plantation cane yields had for many years been greatly reduced by a form of chlorosis, which had come to be known as Pahala blight. The corrective value of sulphur has now been thoroughly established.

The research work connected with this problem was published in the 1926 *Planters' Record* (1) and preceding quantitative field experiments. The evidence at that time strongly indicated that some factor, probably the high ash content of the plant, was interfering with the proper functioning of the iron. Iron determinations, by the gravimetric method, which admittedly are not well adapted for determining such small amounts of iron as are present in plants unless a very large sample is used for analysis, indicated no relation to the chlorosis. On the other hand, injecting iron into the growing stalk of chlorotic cane, and even injecting dilute sulphuric acid to increase the mobility of the iron already present in the plant, completely eliminated the chlorosis and changed the leaves to a rich green color. Therefore, while we recognized that there are a number of physiological disturbances outwardly manifested by chlorosis, iron appeared to be the principal involved factor in the Pahala type.

Lee and McHargue (2) obtained evidence which led them to conclude that Pahala blight was caused by a deficiency of manganese. In view of this, and in view of the fact that we did not use extremely accurate methods in making our iron determinations and made no manganese determinations whatever, we decided to make analyses of cane leaves from our sulphur experiment at Pahala while such plants were available. This should give information regarding the effect of sulphur upon the composition of the cane plant. For comparative analyses we obtained other leaf samples from Pahala and some from other island districts. In making the analyses we used some very accurate colorometric methods developed by Hansson of this laboratory, and we believe the results are absolutely accurate. The following is a description of the samples: All samples represent the five youngest leaves upon the stalk, discarding the rolled or zero leaf. Each sample represents a composite of five leaves from five cane stalks.

The first three samples are from our sulphur experiment at Pahala in which a blight-susceptible variety, Yellow Bamboo, was grown.

1. Chlorotic leaves, crop cane, not a part of the experiment.
2. Chlorotic leaves, from check plot, received no sulphur.
3. Normally green leaves, no chlorosis, from sulphur plot.

The next three samples were taken from Field 21-B at Ewa Plantation. This is a coral field where cane is always severely chlorotic. An experiment was installed in the field, on the basis of Florida experiments where manganese sulphate gave excellent results as a corrective agent for chlorosis on high lime soils. All three samples were taken from a manganese-sulphate plot (150 pounds per acre). No response was obtained from the application of this material and cane in all stages of chlorosis was present in this plot.

4. Slightly chlorotic leaves, H 109.
5. Green leaves, H 109.
6. Severely chlorotic leaves, H 109.

In Lee's investigations he found evidence of manganese deficiency at Kilauea where cane will sometimes show a slight chlorosis. In view of this, and on the basis of some other observations at Kilauea, a rather extensive experiment was installed to determine the effect of manganese salts on cane. The two following samples were taken from this experiment. The cane is Yellow Tip variety and no chlorosis developed in the experiment.

7. Leaves from plot X, check plot, no manganese, no chlorosis.
8. Leaves from plot C, this plot received ½ ton per acre manganese sulphate, no chlorosis.

The next two samples are normally green Yellow Caledonia leaves, taken from the Experiment Station plots at Kailua, Oahu.

9. Normal Yellow Caledonia leaves, Kailua, Oahu.
10. Normal Yellow Caledonia leaves, Kailua, Oahu.

All the rest of the samples were taken at Pahala. The two from the Mudflow field represent normal Yellow Caledonia cane from a field that never develops chlorosis. The sample from Lower Stone field and the one from Lower Keaiwa field, non-chlorotic D 1135 cane, represent fields which produce chlorotic Yellow Caledonia.

11. Normal Yellow Caledonia leaves, Mudflow field.
12. Normal Yellow Caledonia leaves, Mudflow field.
13. Normal D 1135 leaves, Lower Stone field.
14. Normal D 1135 leaves, Lower Keaiwa field.

The following six samples were taken from a chlorotic area in Lower Whitney field for comparing chlorotic and non-chlorotic leaves from the same stool and from different stools:

15. Chlorotic leaves, Yellow Caledonia
16. Green leaves, Yellow Caledonia

} from different stools.

17. Chlorotic leaves, Yellow Caledonia
18. Green leaves, Yellow Caledonia

} growing in the same stool.

19. Chlorotic leaves, Yellow Caledonia
20. Green leaves, Yellow Caledonia

} growing in the same stool.

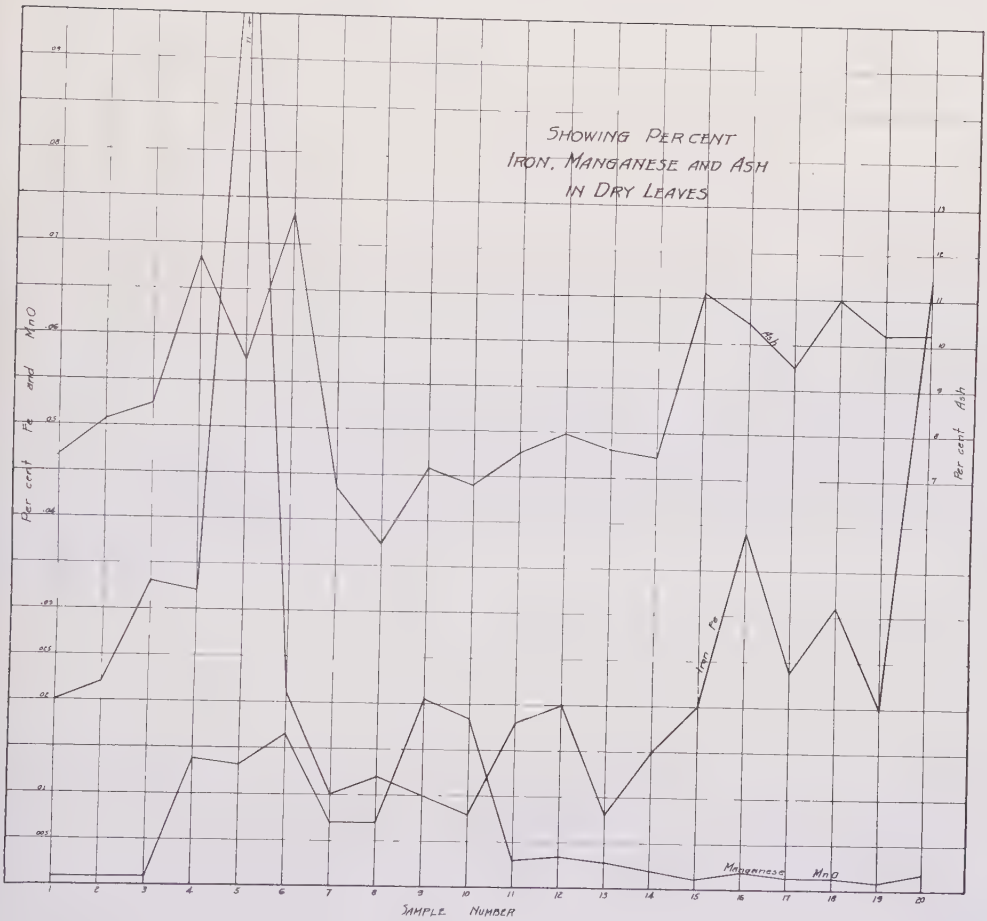
SHOWING PER CENT
IRON, MANGANESE AND ASH
IN DRY LEAVES
Per cent Fe and MnO
Per cent Ash
Ash
Iron Fe
Manganese MnO
SAMPLE NUMBER

Fig. 1

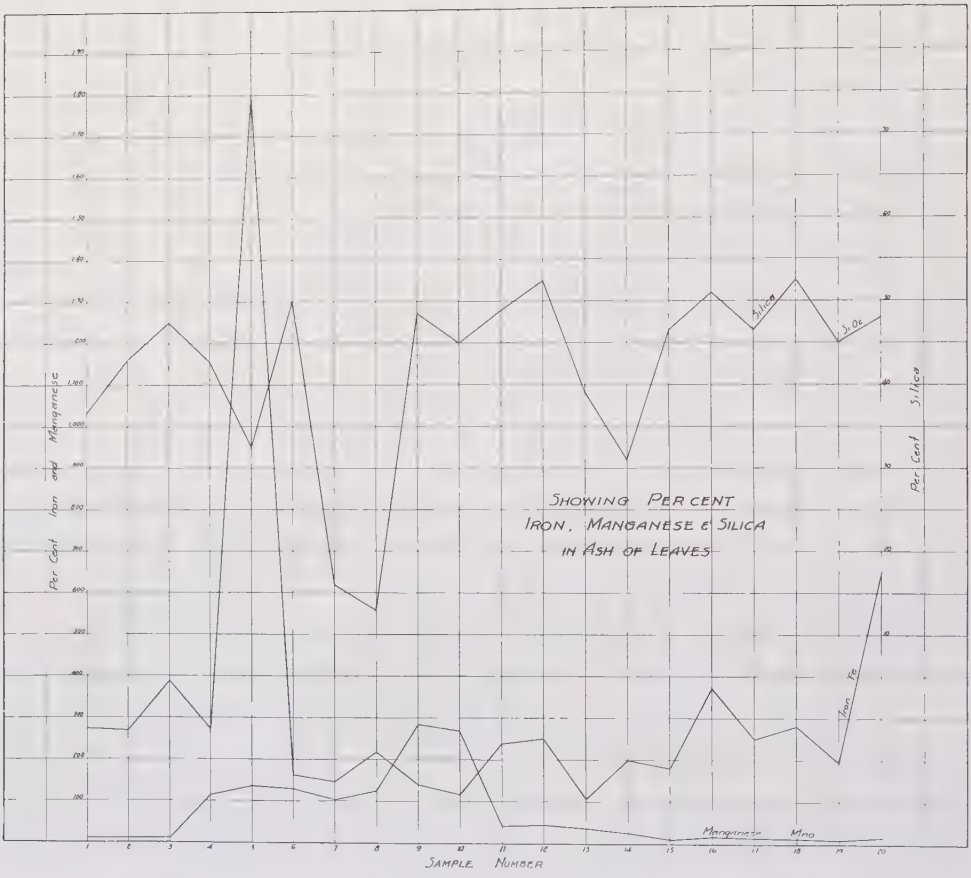
SHOWING PER CENT
IRON, MANGANESE & SILICA
IN ASH OF LEAVES
Per Cent Iron and Manganese
Per Cent Silica
SAMPLE NUMBER
Silica
Fe
Mn

Fig. 2

The relative solubility of iron and manganese in Pahala soils was determined, using one per cent citric acid as a solvent. The results are given in Table II, but do not show any relation to the presence or absence of blight.

The analyses of the leaves are given in the following table and are shown graphically in Figs. 1 and 2:

TABLE I

Sample No.	Condition of leaves	Ash	Silica SiO_2	Calcium Ca	Manganese MnO	Iron Fe	Silica SiO_2	Calcium Ca	Manganese MnO	Iron Fe
			Per Cent Dry Matter				Per Cent Ash			
1	Chlorotic	7.33	2.69	.142	.0008	.020	36.7	1.93	.011	.273
2	Chlorotic	8.15	3.51	.122	.0009	.022	43.1	1.50	.011	.270
3	Green	8.51	4.04	.177	.0010	.033	47.5	2.08	.012	.388
4	Chlorotic	11.71	5.02	.218	.0137	.032	42.9	1.86	.117	.273
5	Green	9.47	3.08	.192	.0132	.171	32.5	2.03	.139	1.800
6	Chlorotic	12.68	6.34	.265	.0166	.021	50.0	2.09	.131	.165
7	Green	6.71	1.08	.614	.0070	.010	16.1	9.15	.104	.149
8	Green	5.50	0.71	.600	.0070	.012	12.9	10.90	.127	.218
9	Green	7.15	3.48	.244	.0204	.010	48.7	3.41	.285	.140
10	Green	6.82	3.06	.246	.0184	.008	44.9	3.61	.270	.117
11	Green	7.54	3.67	.214	.0031	.018	48.7	2.84	.041	.239
12	Green	7.97	4.18	.244	.0035	.020	52.4	3.06	.044	.251
13	Green	7.60	2.96	.174	.0029	.008	38.9	2.29	.038	.105
14	Green	7.46	2.31	.170	.0020	.015	31.0	2.28	.027	.201
15	Chlorotic	11.11	5.19	.402	.0012	.020	46.7	3.62	.011	.180
16	Green	10.46	5.35	.461	.0020	.039	51.1	4.41	.019	.373
17	Chlorotic	9.51	4.44	.389	.0014	.024	46.7	4.09	.015	.252
18	Green	11.00	5.80	.490	.0014	.031	52.7	4.45	.013	.282
19	Chlorotic	10.23	4.63	.436	.0010	.020	45.2	4.26	.010	.195
20	Green	10.28	4.95	.533	.0018	.067	48.1	5.18	.017	.651

TABLE II

Showing Per Cent Iron (Fe_2O_3) and Manganese (Mn_3O_4) in Pahala Soils Soluble in 1 Per Cent Citric Acid from Blight and No Blight Fields

Condition of Field	Iron Fe_2O_3	Manganese Mn_3O_4
Blight	0.88	.032
Blight	0.86	.041
No blight	0.42	.020
No blight	1.10	.017
Blight	0.76	.033
No blight	0.86	.032
Blight	0.46	.016
No blight	0.48	.011
Blight	0.76	.032
No blight	0.68	.065

Ash: The high ash in the leaves from Whitney field, a field noted for having been a bad blight field, tends to confirm our original opinion that a high ash reduces the mobility of the iron in the plant under Pahala conditions. The relative ash content of green and chlorotic leaves from Ewa Plantation is also significant in this connection, as representing a similar relation in limestone chlorosis.

Manganese and Iron: In the leaves taken from our experiment in Naahala field, the manganese has been increased only .0001 per cent (an 11 per cent increase), while the iron has been increased .012 per cent (a 57 per cent increase) by sulphur fertilization, which completely eliminated the chlorosis. On the basis of percentage in the ash, the increases are respectively .001 per cent MnO and .118 per cent Fe. In the Yellow Caledonia from Mudflow field, manganese is notably higher and iron slightly lower than in Naahala field, which is also true for the leaves from Stone and Keaiwa fields. Both of the latter are blight fields but were being cropped to D 1135 at the time leaf samples were taken. Samples 15 and 16 from Whitney field, leaves from different stools, show higher iron and manganese in the green leaves, but the manganese in the chlorotic leaves is still appreciably higher than in the green leaves from the sulphur experiment. In samples 17 and 18, both of which were taken from the same stool, there is no difference in the manganese but a much higher content of iron in the green leaves. In samples 19 and 20, which like 17 and 18 represent chlorotic and green leaves growing in the same stool, there is a higher manganese in the green but a 235 per cent greater iron. The leaves from Ewa, representing typical coral chlorosis, are all high in manganese, while the higher iron content of the green leaves is outstanding. The Yellow Tip leaves from Kilauea are notably high in manganese and low in iron, and there is no increase in the manganese content of the leaves from the manganese-sulphate application at the rate of 1,000 pounds per acre placed in the furrow near the seed. This soil is very low in manganese, while the Pahala soils are all well supplied with this element. The Yellow Caledonia leaves from Kailua are also high in manganese and low in iron. The Kailua area has just recently been changed from a rice field to cane, which probably accounts for the high availability of manganese.

The data show beyond question that cane grown at Pahala is low in manganese as compared with some other island districts, but there is very little difference in the green and chlorotic leaves and no increase from sulphur fertilization, which completely eliminates the chlorosis. On the other hand, there is a big difference in the iron content of the green and chlorotic leaves, with the former much higher than the latter, and this has been greatly increased by sulphur fertilization.

It is true that iron sulphate applied to the leaves at Pahala injures the tissues and that manganese sulphate dusts restore the green color of chlorotic leaves without injury. Further, in the large amount of work that has been done in the last few years upon the role of manganese in plant nutrition, it has been conclusively demonstrated that manganese has an important role in plant economy and that, like iron, it functions in large part as an aid to chlorophyl synthesis.

On the other hand, we have demonstrated in our work that chlorotic leaves under field conditions are characteristically high in ash, which may interfere with

mobility of iron or manganese, and that the soils in the blight fields are of a higher pH (1), which may lower the availability of iron in the soil. In addition, we have shown beyond question that the plants may be restored to normal green color and vigorous growth by increasing the acidity of the soil (1) (better availability of iron and manganese), and by increasing the acidity of the plant juice (1) with the aid of sulphuric acid injections into the cane stalk, which, too, would increase the mobility of iron within the plant. Finally, we have demonstrated that if iron sulphate is injected (1) into the stalk instead of being applied to the leaves where it burns the leaf tissue, there is a complete restoration of the cane to normal color and vigor.

The data which we have submitted in Table I lead us to believe that both iron and manganese are very necessary in chlorophyl synthesis, but that if one is absorbed by the plant in normal amounts a minimum absorption of the other will entirely satisfy the plant. This is indicated by the high iron and low manganese absorbed by cane growing on Pahala soils, and the high manganese and low iron absorbed by plants on the Kailua and Kilauea soils. In view of the fact that sulphur fertilization has not increased the absorption of manganese we are led to believe, on the basis of the large amounts of manganese absorbed on the other soils, that different soils may have rather definitely defined equilibrium concentrations for manganese. Further, in view of the fact that the effect of sulphur has shown itself in a greater assimilation of iron, and that the greatest difference in chlorotic and green leaves is in the iron content rather than the manganese content of the leaves, the results indicate that the iron deficiency and mobility is the greater economic factor in the type of chlorosis found at Pahala and usually called Pahala blight.

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Oriental Rice Borers and Their Parasites

By Fred C. Hadden

In March, 1928, the caterpillar of a moth was found destroying the stems of rice in the paddy fields at Honouliuli, Oahu. This moth is a pyralid, and has been definitely identified as *Chilo simplex* (Butler). The caterpillars chew their way up and down inside the rice stems, and stems thus bored turn brown, die and usually break and fall over, and no head of rice is produced on that stem. Notes on this rice borer were published by R. H. van Zwaluwenburg, E. W. Rust and J. S. Rosa in *The Hawaiian Planters' Record,* Vol. XXXII, No. 4, October, 1928, and the adult, pupae and larvae were figured.

Because this pest is one of the major rice pests in the Orient, and closely related to other moth borers which attack rice or sugar cane, it was thought highly advisable to undertake the introduction of parasites to control it in Hawaii. When first discovered, it was not known whether this insect would attack sugar cane, or whether it would develop a taste for cane in the future. Since the parasites of *Chilo* are not confined entirely to it, but also attack other rice and sugar cane moth borers, the establishment of *Chilo* parasites would not only aid the rice growers, but would also lessen the injury to cane by *Chilo simplex* if it should take to attacking cane, and be at the same time potential enemies of any cane moth borers that might accidentally become introduced into the Islands in the future.

A cooperative project was arranged in which D. T. Fullaway, of the Territorial Board of Agriculture and Forestry, and the writer, of the Experiment Station, H. S. P. A., were sent to the Orient in March, 1928, to investigate the natural enemies or parasites of *Chilo,* and to attempt their introduction to Hawaii.

This paper is an account of the work done in Japan, Formosa and China by Mr. Fullaway and the writer, and pertains to the methods of collecting, shipping, and rearing of *Chilo* parasites discovered in the Orient. On arriving in Japan, Mr. Fullaway stayed in Kobe, obtaining and shipping large numbers of egg-parasites during the first part of the year, while the writer proceeded on to Formosa in order to ascertain the status of the rice borer in relation to sugar cane, and to search for larval parasites. The entire west coast and part of the northeast coast of Formosa were covered in May and observations made in the extensive rice and sugar cane fields of that island. *Chilo simplex* caterpillars were found everywhere in rice, but never in sugar cane, although the cane fields were adjacent to badly infested rice. Following this, investigations were made in China. From a general casual observation of borer conditions throughout Japan, and in China along the coast from Hongkong to Shanghai, about 10 to 15 per cent of the entire Oriental rice crop is destroyed by rice borers.

However, *Chilo simplex* is not the only insect involved. There are two major moth borers in rice in Japan, and three in China; these in their order of importance are:

1. The "paddy borer" of Japan—*Schoenobius incertellus* Walker.
2. The "rice borer" of Hawaii—*Chilo simplex* (Butler).
3. *Nonagria inferens* Walker.

The adult insects are moths which do not do any damage to crops. The moths lay eggs. Tiny caterpillars hatch from these eggs; these are the rice borers and are what do the damage to the rice. They bite their way into the midribs of the leaves, bore down into the stems and kill the stalks. Stems thus bored turn yellow or brown, die and do not produce a head of rice. In some areas of a few acres each, in Foochow, China, over 80 per cent of the rice was destroyed. In these areas, parasites were scarce or were destroyed by hyperparasites.

Schoenobius incertellus is the "paddy borer" of Japan; it is also called Yaa, Tsuwyaa, Zuimushi and Itten-o-meichyu in Formosa and Japan. This insect has been reported as found in Ceylon, India, Burma, China, Java, Japan, Siam and the Philippines. It has been found attacking only rice by other entomologists, but the writer found larvae and pupae of this insect in Foochow, in rice, red rice and "gasung" (*Zizania aquatica* L.). The paddy borer is apparently the commonest and most destructive of the rice borers; it is extremely widespread, being found throughout the Oriental region. According to observations of the writer, *Schoenobius* was usually associated with *Chilo* and *Nonagria* in infested rice fields, but in some areas *Schoenobius* was doing nearly all the damage, as the other two borers were found extremely rare or not at all. This was also true of *Chilo,* for in some areas *Chilo* caterpillars were the predominant borers in the rice stems; the others were not found or were very scarce.

In parasite breeding work in Foochow, *Schoenobius* was not as highly parasitized as *Chilo,* in some cases less than one per cent being parasitized. This may indicate that the native home of *Schoenobius* is not around Foochow. The only parasite reared from *Schoenobius* boring in gasung was *Chelonus chilonis* Cushman.

Chilo simplex is the rice borer in Hawaii. It is a major rice pest in Japan, Formosa and China. It was found in numbers in southern Japan, Formosa and along the central coast of China from Shanghai to Hongkong. It was always more heavily parasitized than *Schoenobius.* This *Chilo* is the predominant rice borer in Taihoku, Formosa; in the south it is scarce. *Chilo* larvae were found most numerous in rice, rarely in red rice and *Zizania.* About twelve species of parasites were bred out of *Chilo* larvae in Foochow. Three species were sent to Honolulu in numbers and arrived alive and were liberated. These were *Amyosoma chilonis* Viereck, *Dioctes chilonis* Cushman, and *Centeterus alternecoloratus* Cushman. Other species were also shipped but arrived dead or too weak to be liberated. A few each of the other species were also liberated: *Cremastidea chinensis* Vier., Tachinids and *Chelonus chilonis* Cushm.

The life history of *Chilo simplex* is briefly as follows: The adult is a small, gray moth which lays masses of eggs in the spring on the young rice leaves of paddy growing in the seed beds, or in the fields. After the rice is a foot high the eggs are usually laid on the stems under the leafsheaths, or inside the leafsheath. There are 50 to 200 eggs in each mass or batch. The eggs are flat, oval disc-

shaped, and overlap each other like the shingles on a roof. They hatch in about a week. The young caterpillars or "rice borers" crawl and swim to other plants, but some bore into the leaves and stems of the plants the eggs are laid on. They bore into the midrib of the leaf, down the midrib and into the base of the stem. As many as fifteen or twenty small larvae have been found in one midrib of rice or *Zizania*. When first hatched the borers are very small, about one millimeter long, when full-grown about an inch long. They often migrate from one stem or plant to another one.

Chilo simplex overwinters in Foochow for four or five months in the rice straw (stems) as a full-grown caterpillar. There are three or four overlapping generations in the summer time.

In the summer, the length of time in the various stages is about:

Egg	6	days
Larva	30	"
Pupa	15	"
Adult	7	"
Total	58	"

In cooler weather, the life history is greatly prolonged. This is true especially of the full-grown larvae, which overwinter in this stage for five or six months. Thus the entire life cycle from the egg to the death of the adult may be from two to eight months.

Larvae could be found in the fields throughout the summer, but were small and difficult to find when the rice was small, that is, less than a foot high. Egg masses were not found around Foochow, although moths in cages were ovipositing readily.

Nonagria inferens Walker was found only in small numbers in rice and very rarely in red rice and *Zizania*. It is also found in Formosa.

Method of Procedure in Obtaining Rice Borer Parasites

Egg Parasites in Japan

Mr. Fullaway made his headquarters in Kobe in the Plant Inspection Building. Dr. C. Akiyama kindly loaned us the use of a large room in this building to use as a laboratory. In all our work in the Orient, Dr. Akiyama has been of the greatest assistance in transshipping material, in offering helpful suggestions, and in many other ways he has smoothed the path of difficulty for the foreign entomologists. Mr. Fullaway corresponded with many Japanese entomologists throughout Japan, and soon had collectors sending in *Chilo* eggs from many localities. These egg masses of 1 to 200 were wrapped in soft tissue paper in glass vials and pill boxes, kept in an ice box until just before the steamer left Kobe for Honolulu, then transferred as quickly as possible to the cool room of the Dollar and N. Y. K. steamship liners. A few days later the Experiment Station was sent a wire to meet that particular boat, and get the parasites. In Honolulu, Messrs. Rust and Van Zwaluwenburg received the material, bred the parasites through one or two generations and then liberated them in the fields. Many thousands of these parasites

were sent to Honolulu, a generation raised on Hawaiian *Chilo* eggs, and then liberated. In this way, hyperparasites were eliminated. Mr. Fullaway is to be complimented for the most satisfactory way the egg-parasite work was carried out. Messrs. Rust and Van Zwaluwenburg handled the material in a most satisfactory manner in Honolulu.

Two species of egg parasites were thus shipped:

1. *Phanurus beneficiens* (Zehnt.).
2. *Trichogramma japonicum* Ashm.

The latter is also known as the red-eyed trichogrammatid. In many cases 98 per cent of the eggs in a mass were destroyed by these parasites. The *Trichogramma* was established in Hawaiian rice fields as indicated by later recovery.

Larval Parasites

Ten species of insect parasites, a parasitic nematode, and a predaceous carabid beetle were found attacking *Chilo* larvae in Foochow. Ten to fifteen Chinese coolies were sent out into the rice fields and shown how to collect rice borer larvae. The dead and dying leaves and stems attacked by borers are easily seen, for they turn yellow or brown. They were cut off at the roots, the stem was then split up from the lower end until the borer was located, the stem was then cut off with a knife or scissors just in front of and behind the borer. These pieces were then brought in by the coolies, counted and paid for. Collectors were paid by the month or per piece of rice stem. Wages were $15.00 per month, or stems containing borers were bought at the rate of 5 for 1 cent. One of the favorite tricks of the collectors was to slip in stems not containing borers. Another was to collect for a few hours in localities where two or three borers were found in each rice stem, the rest of the day they sat under the shade of a tree transferring the borers to healthy stems so that they would get paid for each borer. A peculiar characteristic of these coolies was that they preferred to be crooked and lose money, to being honest and making more money. Perhaps the reason for this was that most of them came from a notorious pirate and bandit village.

Later on, the system was finally adopted of paying them 2 cents per parasite cocoon. Then they tried to substitute ant cocoons, which are quite similar to parasite cocoons. The greatest difficulty in working in the Orient is to get any one to do the thing you want him to do in the way you want it done.

The stems containing borers were kept in large glass jars 10 inches in diameter by a foot high, covered with cloth which was held on by rubber bands. Every day fresh pieces of *Zizania* were placed in the jars. The borers would crawl out of the older stems and bore into the fresh pieces. After a week or two adult parasites began to emerge, at the same time all kinds of other insects and hyperparasites would appear.

At times mites would breed in great numbers in the older decaying rice stems; they would fairly swarm over the parasites and in this manner would be carried to another place. Parasites thus attacked would try to scratch the mites off but were never successful in so doing, and as a result soon died. This made it necessary

to split open all the stems after a week has passed and to remove all parasite cocoons, and transfer them to new breeding jars; this successfully eliminated mites, although some of the parasites were killed due to too rough handling.

The adult parasites, after emergence, were fed honey and water and again transferred into clean, wide-mouth glass jars, which were stoppered with cotton, and placed in an ice box. It was necessary to personally conduct these up to Shanghai, because no one else could be trusted to give them the proper care. No matter how carefully written instructions are given something is always done wrong, and as a result the entire shipment arrives dead.

From the ice box in Foochow the parasites were rushed into the Chinese steamers anchored down the Min River at Pagoda anchorage, and into the ice box on the steamer. At Shanghai they were taken out, fed, transferred again to clean jars and put in the ice box in the Y. M. C. A. building. When the Dollar liner was about ready to sail to Honolulu, they were taken on board and put in the vegetable room at 40° F.

All the insects were kept from one to two weeks in Foochow before leaving on the Chinese steamer to Shanghai. They were kept in Shanghai from two to five days before leaving for Honolulu. The entire trip took from eighteen to twenty-four days, and the insects were always at least a month old (as adults) upon arrival in Honolulu.

The larval parasites arriving alive in Honolulu in fairly good condition were: *Amyosoma, Centeterus* and *Dioctes*. Very few of the others arrived alive, except when personally conducted during the entire journey.

Parasite cocoons were also shipped. They were packed in 4-ounce tin salve boxes which were lined with soft tissue paper to absorb excess moisture and kept on ice at 40-50° F. throughout the trip, except for the short time (½ hour) it took to take them from the shore to the boat and the boat to the shore. The tins were put in thermos bottles to keep the temperature from changing, for, as soon as the cocoons warmed up, adults began to emerge in a few minutes. We now know that there is an overwintering period in which they stay in the cocoon in the cooler months; and that it is possible to ship them in the fall.

However, fall-shipped parasite cocoons are very heavily hyperparasitized by Chalcids, and only about 5 per cent of the true parasites emerge. The "hypers" come out by the hundreds, and great care must be taken to prevent their escape.

All foreign parasites received by the Station are handled in the quarantine room. This is a small room with a low ceiling, and finely screened windows.

Before entering this room it is necessary to pass through a small dark room, and two doors which are almost air-tight. The parasite cocoons are placed in large glass jars covered with cheesecloth. As the insects emerge, the true parasites are removed to new jars, and the "hypers" killed.

Emerging parasites were kept in jars to facilitate mating; some were kept to experiment with rearing in the laboratory, others were released in the fields.

Ichneumonid Parasites

The Ichneumonid parasites of rice borer larvae have a visible ovipositor. The manner in which they parasitize their host has not been definitely studied by the writer. They probably crawl around, up and down the rice stems until they locate a borer, they then pierce the stem with the ovipositor (or stinger) and either oviposit the egg inside the stem or penetrate the skin of the rice borer larva and lay the egg inside the body of the host. This must also be true of the Braconids with visible ovipositors or stingers. The parasites with visible ovipositors are:

Amyosoma chilonis Vier.
Dioctes chilonis Cushm.
Cremastidea chinensis Vier.
Amauramorpha schoenobiae (Vier.)

Chelonus chilonis Cushman is a braconid without a visible ovipositor. It probably parasitizes the host in the same manner as *Chelonus sonorensis* of Mexico. *C. sonorensis* inserts its eggs in the eggs of the rice borer and inside of the almost completely developed embryo. Later, the rice borer larva hatches from its egg and commences to eat and grow. In the meantime the *Chelonus* larva hatches and grows, living as a true internal parasite on the blood of the rice borer. It eventually kills the rice borer larva. This is a peculiar characteristic of nearly all parasites; they eventually kill or produce sterility in the host.

Tachinid Parasites

Only a few Tachinids (three species) were reared from rice borers. Their method of attacking the host is not known. They probably oviposit on migrating borers as they move from one stem to another. They are evidently not very effective parasites.

Carabid Beetles

Shortly after the rice harvest in Foochow a small black Carabid was found in small numbers in the rice stubble. Larvae, pupae and adults were found within the rice stems. In uncut rice fields the beetles were scarce. They were probably attracted into the fields from the surrounding country by the borers that were migrating from the stubble. Attempts to breed the beetles in cages were unsuccessful. They soon died in captivity.

Nematodes

At certain times nematodes killed and emerged from 20 to 50 per cent of the rice borer larvae. As many as five or six nematodes emerged from one caterpillar. Because it was thought that the nematodes would be detrimental to the insect parasites, no attempt was made to introduce them into Hawaii.

List of Parasites Studied

The following parasites were bred from rice borers or rice stems in the Orient:

1. *Amyosoma chilonis* Viereck
2. *Microbracon* sp.
3. *Shirakia schoenobiae* Vier.
4. *Centeterus alternecoloratus* Cushm.
5. *Dioctes chilonis* Cushman
6. *Chelonus chilonis* Cushm.
7. *Cremastidea chinensis* Vier.
8. *Amauramorpha schoenobiae* (Vier.)
9. *Goryphus basilaris* Hlgn.
10. *Apanteles flavipes* Cam.
11. *Apanteles chilocida* Vier.
12. *Apanteles* sp.
13. *Trichogramma japonicum* Ashm.
14. *Phanurus beneficiens* (Zehnt.)
15. A gray Tachinid fly (Sp. K.)
16. A black Tachinid fly (Sp. J.)
17. A predaceous black carabid beetle (Sp. L.)
18. A nematode worm.

Some of these parasites were liberated on Oahu in the following numbers:

Amyosoma chilonis about	250
Centeterus about	40
Dioctes about	30
Cremastidea about	8
Microbracon sp. about	8
Sp. "K" about	6
Sp. "J" about	2

Hyperparasites

Four or five species of chalcids were reared from parasite cocoons, also two or three species of small hymenopters not chalcids.

Mr. Fullaway* lists parasites released in 1928 as follows:

Egg Parasites:

Trichogramma japonicum	41,975
Phanurus beneficens	37,965

* Report of the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii for the Biennial Period ended December 31, 1928, p. 46.

Larval Parasites:

Japanese Amyosoma	212
Japanese Apanteles	289
Centeterus alternecoloratus	40
Dioctes chilonis	141
Amyosoma chilonis	86
Cremastides chinensis	20

Thus a total of about 80,000 egg-parasites, and about 900 larval parasites on the rice borer have been liberated in Hawaii at different times in the following localities: Honouliuli, Kaneohe, Pearl City Road, Waialua and Honolulu on Oahu; also at Nawiliwili, Kauai.

Amyosoma chilonis Vier. was reared for liberation in the summer of 1929. It is now definitely known that the following parasites have become established:

Trichogramma japonicum
Dioctes chilonis
Amyosoma chilonis

They have been recovered in Hawaiian rice fields in the summer and fall months of 1929. Mr. Fullaway says in the Report of the Entomologist for the week ended November 30, 1929, Board of Agriculture and Forestry: "Two of the larval parasites (of rice borer) were recovered from the field during the week confirming their establishment. They are *Dioctes chilonis* and *Amyosoma chilonis*."

Some Effects of Molasses Fertilization

By W. T. McGeorge

During the last few years considerable interest has been manifested regarding molasses fertilization on our plantations. On the basis of some early soil investigations and observations, in spite of the high potassium content of the molasses, its application to fields had been scrupulously avoided for fear of injuring cane growth. It now appears that the prejudice against molasses had been largely based upon a misunderstanding of its effects upon the soil under field conditions. Laboratory studies rather than field studies had been the basis of most conclusions. During the past two years we have obtained further information upon the problem, which is of interest.

It is largely to the credit of W. W. G. Moir that the question of molasses fertilization has been reopened, and this has undoubtedly led to a better understanding of the problem. Excellent reviews of the literature, with comments by plantation field men, have been published by Mr. Moir*, so these will not be repeated here.

A part of the investigations reported in this paper were taken up at the solicitation of W. P. Alexander, formerly head of the department of research and control at Ewa Plantation Company, and the rest as a part of a study of the fertility of Kilauea Sugar Plantation Company soils. In the former, we were interested in the conditions under which molasses injured cane growth, as contrasted with other fields in which notable response to molasses was being obtained. In the latter, we were interested in its relation to the availability of potassium and its effect upon the soil colloids. A highly dispersed soil colloid was believed to be associated with the poor fertility of Kilauea soils.

The Causes of Injury

Iron and Aluminum: It has been found that when molasses is applied to growing cane few or many spots may appear in the field in which the leaves turn yellow or, in severe cases, will die. We have obtained some rather definite evidence of the cause of this injury. On close examination of the plants the leaves appeared to have been injured by toxic amounts of iron and aluminum, and this was confirmed by comparative analyses of the cane which showed a greater amount of these elements in the injured cane as compared to normal cane growing near by. This was further confirmed by an examination of the soil. The soil was a heavy clay type, and in the areas where injury occurred drainage was very poor. In some areas, standing water was still present in the furrows. There was a film of iron rust on the surface of the water and soil in the poorly drained areas. This

* Presented at forty-eighth annual meeting of the Hawaiian Sugar Planters' Association, December, 1928.

was caused by the solvent effect of the fermentation products of molasses, the acids, upon iron and aluminum compounds of the soil. The iron had subsequently precipitated as ferric hydroxide or carbonate on contact with the air. Qualitative tests for iron and aluminum accumulations at the nodes of the cane stalk also gave evidence of toxicity from these elements. We therefore believe that iron and aluminum salts are the principal cause of injury from molasses, and that this will only occur in poorly drained soils where the molasses is allowed to accumulate and to ferment under anaerobic conditions. In well drained soils it would be the better policy to apply lime with molasses if the "active" aluminum content of the soil is high.

Nitrites: We were surprised to learn on examining the soils from the areas at Ewa Plantation that larger amounts of nitrite nitrogen were present in the soils where the cane had been injured, while there was no difference in the amount of nitrate, both showing only traces of this form of nitrogen. The soil, where no injury to cane had followed molasses treatment, contained no nitrite, while that from the injured area contained .55 part per million of dry soil. All organic or ammonia nitrogen must, during the process of nitrification, pass from ammonia to nitrite before being changed to nitrate. The change is, however, very rapid and only traces of nitrite are found in soils except where oxygen is deficient, as the latter is vital to the final step in nitrification. Having no information on the effect of nitrite nitrogen upon sugar cane, some experiments were conducted in order to determine this.

Four pots of 50 pounds capacity were filled with Experiment Station soil and four with silica sand. Each pot was planted with three-eye H 109 seed. Once each week nitrogen was added to two of the sand pots and to two of the pots of soil at the rate of 0.1 gram nitrogen from sodium nitrite. To the other four pots the same amount of nitrogen from sodium nitrate was added. Potassium phosphate was added to each of the sand pots to supply these two elements. The plants were grown from December 29, 1928, to March 23, 1929, and at no time was there any toxic effect from the sodium nitrite. At the completion of the experiment the sand and the soil from the pots were analyzed and the nitrate and nitrite present in dry soil or sand are given in the following table:

	P. P. M. as Nitrate	P. P. M. as Nitrite
Sand—nitrite nitrogen	5.2	.13
Soil—nitrite nitrogen	40.3	1.00
Sand—nitrate nitrogen	4.8	.06
Soil—nitrate nitrogen	40.3	1.34

The soil from the molasses injured cane at Ewa contained .55 p.p.m. nitrite nitrogen, so it hardly seems possible that nitrite was associated with the injury.

Nitrogen Availability

In the main, controversy over the value of molasses has involved its relation to soil nitrogen and the activities of soil organisms associated with nitrogen transformations within the soil confines. It has been the general belief that denitrifica-

tion follows molasses fertilization. In order to study some of these factors, Mr. Alexander installed an experiment and placed it at our disposal. It was located in Field 17B, Ewa Plantation Company, and consisted of sixteen plots; four of these were molasses plots; five were check plots; and seven were buffer plots separating the check plots from the molasses plots. The soil is a red clay loam. The area is a gently sloping one with good drainage in the upper plots, 1 to 13, merging into a heavier soil, less well drained in the lower plots, 14 to 16. It was hoped that drainage was sufficiently poor in the latter to cause injury. The cane was H 109 ratoons. The previous crop had been harvested August 28, 1928, to September 1, 1928. Molasses was applied at the rate of 17.6 tons per acre on September 17, in the first irrigation water.

Four plots were chosen for study, namely, 9 and 16 for the check plots and 11 and 14 for the molasses plots. The first set of samples was taken on September 17, just before the molasses was applied. At this sampling both the first and second foot of soil were sampled for future use in case injury should develop. The second set of samples was taken, representing the first foot only, September 26, just 9 days after the molasses had been applied. The third set was taken on November 20, the fourth on January 9, the fifth on January 25, and the sixth on March 6.

Data obtained from these samples included moisture and nitrate content under field conditions, *in situ,* and nitrate formed by incubating the soils in the laboratory. Soil reaction was determined for the first two sets of samples, and in a number of cases nitrite nitrogen was determined. The nitrate formed by incubation or the nitrifying power of the soil was determined by incubating 100 grams of soil for 28 days, at optimum moisture content, in the laboratory. The data obtained are given in the following tables:

TABLE I

September 17

Showing Moisture Reaction, Nitrate, and Nitrite Content of Soil *In Situ* and Nitrifying Power. All Except Moisture Are on Dry Basis.

Plot		Per Cent H_2O	pH	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrite in Soil	p. p. m. N as Nitrate † Formed by Incubation
9a*	Check plot	13.8	7.6	2.6	.019	6.1
9b		15.9	7.3	2.6	.009	6.3
11a	Molasses plot	14.7	7.6	2.6	.011	6.2
11b		15.5	7.4	3.0	.005	5.8
14a	Molasses plot	17.7	7.7	4.6	.006	6.8
14b		18.4	7.5	3.3	.007	6.0
16a	Check plot	17.2	7.6	4.6	.012	10.4
16b		18.7	7.4	2.7	.009	7.3

*a—soil; b—subsoil.

†Corrected for nitrate originally in soil. This is true of all the nitrifying power data given in this report.

TABLE II

September 26

Showing Moisture, Reaction, Nitrate, and Nitrite Content of soil *In Situ* and Nitrifying Power. As in Table I, on Dry Basis.

Plot		Per Cent H_2O	pH	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrite in Soil	p. p. m. N as Nitrate Formed by Incubation
9	Check plot	21.6	7.6	2.8	.130	4.6
11	Molasses plot	21.6	7.6	2.8	.070	6.1
13	Check plot	20.8	7.4	2.8	.000	3.2
14	Molasses plot	26.0	7.4	tr	.070	8.1
16	Check plot	25.2	7.4	5.9	.010	3.7

TABLE III

November 20

Showing Moisture, and Nitrate Content of Soil *In Situ* and Nitrifying Power, Dry Basis.

	Plot	Per Cent H_2O	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrate Formed by Incubation
9	Check	18.0	9.3	4.5
11	Molasses	19.4	12.8	12.2
14	Molasses	22.8	66.8	23.2
16	Check	21.4	34.8	tr

TABLE IV

January 9

Showing Moisture and Nitrate Content of Soil *In Situ*, Dry Basis.

	Plot	Per Cent H_2O	p. p. m. N as Nitrate in Soil
9	Check	24	17.4
11	Molasses	24	24.6
14	Molasses	25	23.2
16	Check	24	21.7

TABLE V

January 25

Showing Moisture, Nitrate and Nitrifying Power, Dry Basis

	Plot	Per Cent H_2O	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrate by Incubation
9	Check	24	52	7
11	Molasses	24	52	14
14	Molasses	25	51	— 7
16	Check	25	146	—61

TABLE VI

March 6

Showing Moisture, Reaction, Nitrate Content of Soil *In Situ* and Nitrifying Power, Dry Basis.

Plot		Per Cent H_2O	pH	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrate Formed by Incubation
9—1	Check	18	8.0	3.9	8.3
9—2	Check	22		4.2	6.6
9—2	Check	18		3.9	6.9
11—1	Molasses	16	8.0	15.8	11.4
11—2	Molasses	19		15.9	48.6
11—2	Molasses	18		16.3	16.0
14—1	Molasses	24	7.7	8.6	11.6
14—2	Molasses	22		8.3	20.4
14—2	Molasses	24		10.8	21.4
16—1	Check	22	7.7	7.2	5.6
16—2	Check	22		10.5	16.9
16—2	Check	24		17.8	3.7

Plots 9 and 11 are in the better drained, higher level of the experiment, while 14 and 16 are in the heavy soil at a lower level than 9 and 11. All the determinations were made upon the fresh soil direct from the field and are calculated to a common basis of water-free soil.

Table I: There is little variation in soil reaction but slightly higher nitrate nitrogen in the lower area, plots 14 and 16, as well as better nitrifying power. It is evident from column one that this higher nitrate and better nitrifying power are associated with a better moisture-holding capacity. So much for the soil properties before molasses fertilization.

Table II: This set of samples was taken September 26, 9 days after the molasses was applied, and an additional check plot, No. 13, was included. The change in soil reaction is practically nil on this soil type and no apparent injury to cane growth was visible. The higher moisture-holding capacity of plots 14 and 16 is again in evidence. The incubation tests show a better nitrifying power in the molasses plots, even at this early date. This indicates that if denitrification processes are active the nitrifying power has been sufficiently increased to more than make up for any loss of nitrate under field conditions. There was no evidence of nitrogen starvation in any of the plots at this period.

Table III: The third set of samples was taken two months after the application of the molasses and shows a great increase in nitrate content *in situ*, as well as an increase in nitrifying power of the soil in the molasses plots. Plots 14 and 16,

1—Sampled with soil augur, 12 inches.
2—Sampled with soil trowel, 6 inches.

with better water-holding capacity, still show higher nitrate, and the cane was making better growth at this time than in plots 9 and 11.

Tables IV and V: On January 9 this field had just been irrigated and the samples obtained with the soil auger were so badly puddled that weighing a representative sample for nitrification was impossible without first drying the soil. Therefore, only nitrate *in situ* was determined. Unfortunately, the January 25 sampling was also made just at the time of irrigation as well as fertilization. The samples taken were in a badly puddled condition and as drying in the air, which would have been necessary to get a representative sample, was out of the question, the results cannot be accepted as accurate. The fertilizer had just been applied and this necessarily entails incomplete diffusion within the soil confines.

Table VI: After the experiences of January 9 and 25, the next sampling date was set for the day preceding the first March irrigation, i.e., March 6. At this time the soil was in an excellent physical condition. Three samples were taken from each of the four plots; one with a soil auger, five borings one foot in depth, and two with a trowel, each from eight spots to a depth of six inches. The soil still continues to show higher nitrate nitrogen in the molasses plots and better nitrifying power. Of the two check plots, better availability of nitrogen continues to prevail in plot 16 where the moisture-holding capacity is higher. At this date there appeared to be a noticeable response to molasses in plot 11, as compared to check plot 9. But there is no observable difference between plots 14 and 16 where the water-holding capacity is higher, and nitrification in the check plot 16 is very good. Cane growth is very good in both plots 14 and 16. The samples taken with a trowel show considerable variation, which indicates less uniformity in the surface 6 inches of soil.

Judging from the preceding, there is no evidence of denitrification but rather a stimulation in nitrification and nitrifying power from the time immediately following that at which the molasses was applied. In order to compare soil from this experiment with that from other fields at Ewa, to which molasses had been applied, soil samples were taken from a number of other fields.

Field 15B: This field received 11¼ tons per acre of molasses July 3 to July 5, 1928. New ratoons were starting just at that time. At first there was a temporary injury which manifested itself in the form of pale green leaves. This injury was not uniform, but was present only in scattered spots and the cane soon grew out of it, after which an excellent response to molasses, as compared to the check plots, appeared. This experiment included a number of plots to which potash had been added in amounts equal to that added in the molasses in order to compensate for this factor. Soil samples were taken September 26, 1928, from check plot 4, molasses plot 3, and a potash plot.

Field 2A: This field received 18 tons per acre molasses May 19 to June 9, 1928, and the soil samples were taken September 26, 1928, 4 months after application, from adjacent molasses and check plots. The cane was showing excellent response to molasses in this field at the time of sampling.

Field 21B: This field received 7¾ tons molasses per acre April 10 to June 11, 1927, and the soil samples were taken November 20, 1928. At this time the ex-

periment was in its second crop. The crop to which the molasses was added had shown no response to the treatment. This is a coral-impregnated field in which the cane is afflicted with limestone chlorosis, and the molasses had been added in order to observe its effect upon chlorosis. This is the only field sampled which had not shown response to molasses.

Field 13C: This field received 28 tons molasses per acre on June 16 to June 21, 1928, and the soil samples were taken November 20, 1928. During the early growth there was some injury, which appeared in small spots, but the cane soon grew out of it and from that period appeared to be making better growth where the molasses had been applied. It is probable that 28 tons is too large an application for this field.

These soil samples were analyzed for moisture and nitrogen, and their nitrifying power determined with the results as given in the following table:

TABLE VII

Showing Moisture, Nitrate Nitrogen and Nitrifying Power of Soils

	Per Cent H_2O	p. p. m. N as Nitrate in Soil	p. p. m. N as Nitrate Formed by Incubation
Field 15B—Potash plot	27	5.9	6.3
Field 15B—Check plot	22	4.3	4.9
Field 15B—Molasses plot	28	3.0	27.6
Field 2A—Check plot	21	18.0	12.0
Field 2A—Molasses plot	17	11.4	14.6
Field 21B—Check plot 59X	25	5.9	7.6
Field 21B—Molasses plot 60M	27	16.4	18.6
Field 21B—Molasses plot 64M	28	8.6	23.1
Field 21B—Check plot 65X	25	3.6	7.5
Field 13C—Check plot	25	3.6	6.9
Field 13C—Molasses plot	26	3.6	17.8

These data tend to confirm the results obtained in our soil studies on the experiment in Field 17B. In every case the better nitrifying power of the soil from the molasses plots, which signifies a greater availability of soil nitrogen, is shown. It is significant that this property is still manifested in Field 21B 18 months after the molasses had been applied. The greener color of the cane leaves growing on the molasses plots further testifies to the better nitrogen availability. The greater difference in nitrifying power, as compared to the difference in nitrate present in the field, testifies to the fact that the cane was using this extra nitrogen as fast as it was being nitrified.

Availability of Potash and Phosphate

Moir found a distinct increase in available potassium and phosphate in the soil following molasses fertilization at Pioneer Mill Company after one year, with a

still greater increase after 5 years. At Ewa we did not find any effect upon phosphate availability, but found that the potassium from molasses had greatly enriched the supply of available potassium in the soil.

The availability of potash and phosphate, as measured by one per cent citric acid, is given in Table VIII, and for two fields the solubility of potassium in water saturated with carbon dioxide is given in Table IX. The data do not show any definite relation to phosphate availability, but in every case the citric soluble potash is greatly increased, except in Field 21B and it is significant that this is the only field in which no response to molasses was obtained. The molasses application in this case was the smallest, 7¼ tons per acre, and the soil differs in being a coral type, which may have influenced the availability of potash. The data in Table IX also show a greater solubility of potassium in water saturated with carbon dioxide, and this is significant in that plant roots feed largely by the aid of carbon dioxide which they secrete. These data show beyond question that potash added in molasses is fixed by the soil in a highly available form.

TABLE VIII

Showing Per Cent K_2O and P_2O_5 Soluble in 1 Per Cent Citric Acid.

Sample and Field	K_2O	P_2O_5
15B—Potash plot	.033	.0213
15B—Check plot	.023	.0190
15B—Molasses plot	.059	.0193
2A—Check plot	.021	.0093
2A—Molasses plot	.052	.0088
21B—Check plot, 59X	.029	....
21B—Molasses plot, 60M	.025	.0293
21B—Molasses plot, 64M	.025	.0102
21B—Check plot, 65X	.016	.0041
13C—Check plot	.026	.0285
13C—Molasses plot	.043	.0285
17B—Check plot, 9X	.011	.0070
17B—Molasses plot, 11M	.042	....
17B—Molasses plot, 14M	.066	.0137
17B—Check plot, 16X	.021	.0300
(September 26 samples.)		

TABLE IX

Showing Per Cent K_2O Soluble in Water Saturated With Carbon Dioxide.

Sample and Field	K_2O
15B—Check plot	.008
15B—Molasses plot	.026
2A—Check plot	.006
2A—Molasses plot	.021

Molasses as an Amendment for Infertile Soils

At Kilauea Sugar Plantation Company, where the soils are very infertile, it is the practise to fallow the fields for a period between the last ratoon and replanting. The value of such a program is usually reflected in a better yield of plant crop and a lack of response to nitrogen. The increase in available nitrogen, due to better aeration, sunlight, etc., is sufficient to supply the requirement of the plant crop. From our observations, there is much in similarity between the effect of molasses on our soils and that of aeration and fallow. Our virgin soils usually show very little nitrifying power but this is greatly increased by plowing. A similar condition also exists in poorly aerated cultivated soils which have become matted and shaded by the heavy growth of cane for some months preceding harvest.

In view of the above, the question naturally arises, will plantation soils which apparently demand a period of fallow respond to molasses, and can molasses fertilization replace fallow in the crop cycle? Kilauea Plantation soils are excellently suited for such an investigation, and in our study of molasses fertilization this phase of the problem has been included and much information has been obtained.

Five different series of pot experiments, involving 100 pots in all, each pot holding 55 pounds of soil, were conducted in this study. The soil selected for this work was taken from Field 24, Kilauea Sugar Plantation Company, a poor field, and in view of the fact that Kilauea soils are highly colloidal and underlain with a very toxic subsoil, which is undoubtedly one factor which makes a fallow necessary, this subsoil was included by using soil 18 to 24 inches. In every case, we obtained better plant growth when complete fertilizer was supplemented by molasses. In every case we obtained better plant growth on aerated soil, as compared with soil which was transferred from the field to the pots without permitting aeration. In the unaerated toxic soil and subsoil no response was obtained with heavy applications of complete fertilizer, except where molasses was also applied. In fact it was evident throughout these experiments that the effect of molasses was quite similar to aeration.

As a matter of interest, two of these experiments are explained in detail:

Experiment D: The soil used in this series had been used in other pot experiments here at the Experiment Station and, while not allowed to thoroughly dry, had been well aerated and had received some previous fertilization.

Experiment E: The soil used in this experiment was taken from the same spot in the field as that used in Experiment D, but was placed directly in the pots without permitting any aeration.

The plan of these experiments was as follows: All pots contained the same weight of soil, 55 pounds; were planted to Yellow Tip seed; were planted on the same day, April 1, 1929; and fertilized on the same day, March 29, just one day preceding planting. Numbers represent grams added of dried blood and nitrate of soda (N), sulphate of potash (K), superphosphate (P), molasses (Mol.) and sugar.

EXPERIMENT D

1. N7
2. N7—Mol. 300
3. N7—Sugar 300
4. N7—Sugar 300—K25
5. N7—K25—P25
6. N7—K25—P25—Mol. 300
7. N7—K25—P25—Sugar 300
8. N7—K25—P25—Sugar 300—K25

EXPERIMENT E

1. N7
2. N7—K25—P25
3. N7—K25—P25—Mol. 300
4. N7—K25—P25—Sugar 300
5. N7—K25—P25—Sugar 300—K25
6. N7—P25—Sugar 300

We sought, in this experiment, information on the effect of aeration on cane growth, the comparative effect of complete fertilizer on aerated and unaerated soil with and without molasses, and the relative influence of the sugar and potassium, in molasses, upon the response obtained.

Growth measurements were made at intervals during the growth of the plants, and these are given graphically in Figs. 1 and 2, together with the final weight of tops and roots. The tops were analyzed and the comparative composition is given in Tables X and XI.

TABLE X

Showing Composition of Plants Grown in Experiment D*

Treatment	Nitrogen N	Ash	Silica SiO_2	Phosphate P_2O_5	Calcium Ca	Magnesium Mg	Potassium K
			Per Cent Dry Matter				
1. N	.587	5.25	1.48	.383	.225	.131	1.48
2. N—Mol.	.602	6.31	1.11	.337	.220	.102	2.22
3. N—Sugar	.531	5.90	1.83	.339	.248	.153	1.51
4. N—Sugar—K	.546	6.76	1.43	.345	.116	.071	2.37
5. N—K—P	.514	7.37	1.45	.378	.139	.076	2.56
6. N—K—P—Mol.	.537	7.26	1.25	.381	.133	.082	2.58
7. N—K—P—Sugar	.495	6.58	1.30	.429	.136	.085	2.37
8. N—K—P—Sugar—K	.458	7.05	1.63	.423	.165	.105	2.52
			Per Cent Ash				
1.			21.9	7.30	4.29	2.49	28.3
2.			17.6	5.35	3.52	1.61	35.3
3.			31.0	5.74	4.22	2.60	25.6
4.			21.1	5.09	1.71	1.05	35.2
5.			19.7	5.13	1.90	1.03	34.8
6.			17.3	5.24	1.81	1.13	35.6
7.			20.0	6.51	2.06	1.30	36.1
8.			23.0	6.00	2.33	1.49	35.8

* Analyses by J. H. Duffy.

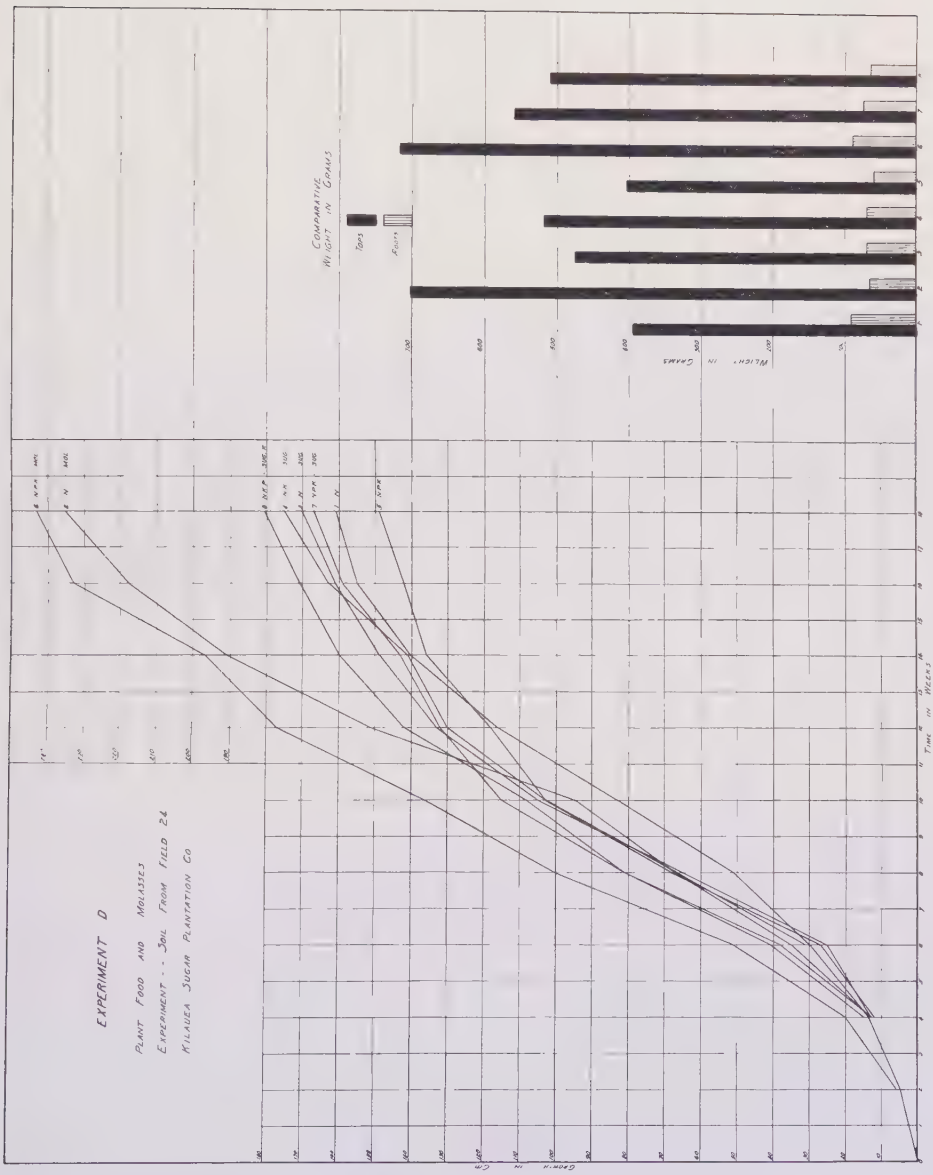
EXPERIMENT D
PLANT FOOD AND MOLASSES
EXPERIMENT - - SOIL FROM FIELD 24
KILAUEA SUGAR PLANTATION CO
COMPARATIVE WEIGHT IN GRAMS
TOPS
ROOTS
WEIGHT IN GRAMS
GROWTH IN CM
TIME IN WEEKS

Fig. 1

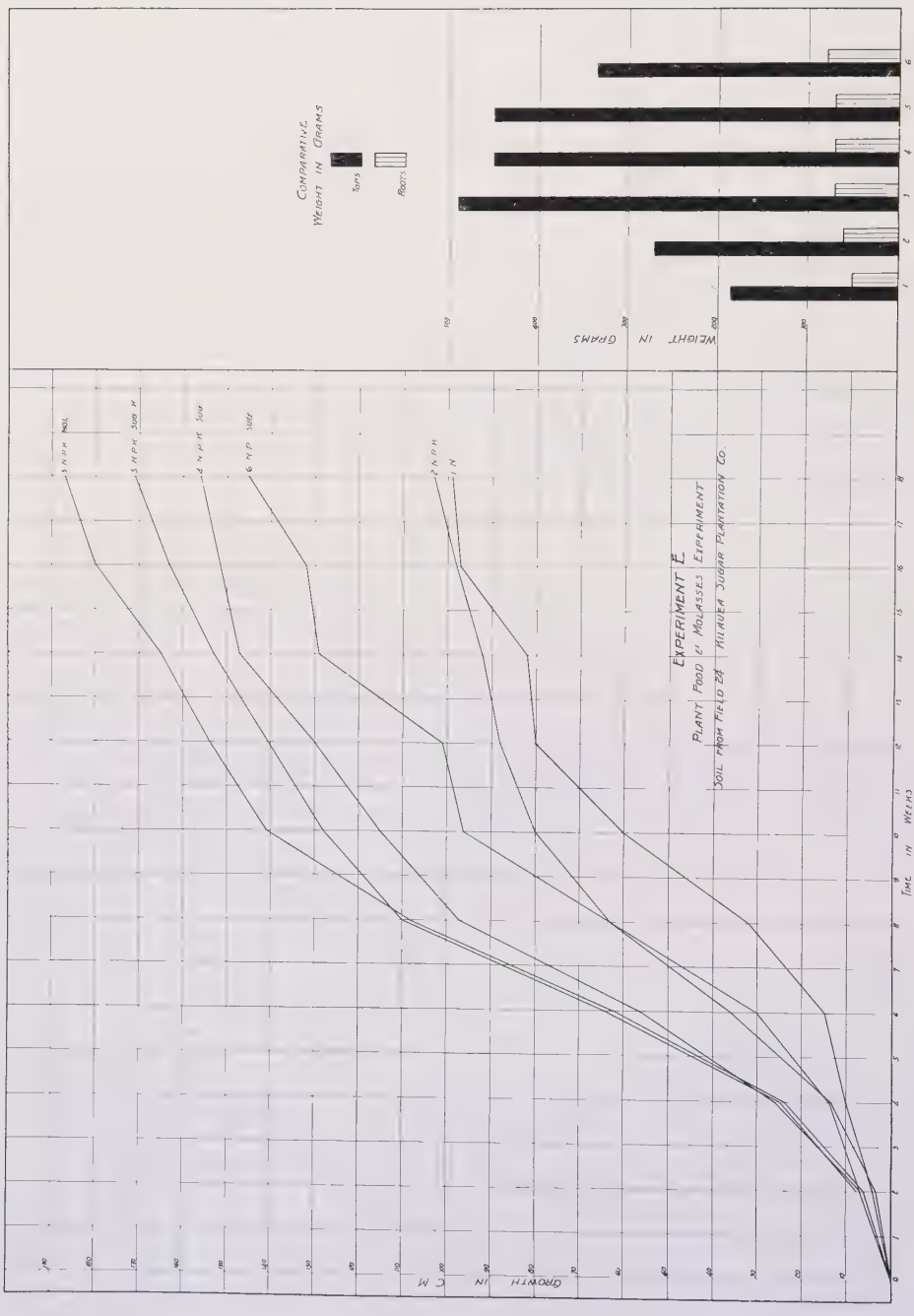
EXPERIMENT E
PLANT FOOD 1% MOLASSES EXPERIMENT
SOIL FROM FIELD 28 HILAUEA SUGAR PLANTATION CO.
GROWTH IN CM
TIME IN WEEKS
WEIGHT IN GRAMS
COMPARATIVE WEIGHT IN GRAMS
TOPS
ROOTS
1 N P K
2 N P K
3 N P K 500 M
4 N P K 500
5 N P K 500 M
6 N P 500

Fig. 2

TABLE XI

Showing Composition of Plants Grown in Experiment E*

Treatment	Nitrogen N	Ash	Silica SiO_2	Phosphate P_2O_5	Calcium Ca	Magnesium Mg	Potassium K
		Per Cent Dry Matter					
1. N	.456	4.17	.82	.300	.384	.267	.86
2. N—P—K	.411	6.20	.60	.340	.146	.088	2.13
3. N—P—K—Mol.	.412	5.55	.43	.321	.168	.108	2.20
4. N—P—K—Sugar	.433	5.56	.59	.392	.157	.087	2.07
5. N—P—K—Sugar—K	.493	6.12	.97	.581	.174	.112	2.42
6. N—P—Sugar	.525	3.96	.50	.245	.385	.348	.65
			Per Cent Ash				
1.			19.7	6.70	1.97	6.39	20.77
2.			10.5	5.98	2.56	1.55	37.47
3.			9.4	5.78	3.03	1.94	39.57
4.			10.6	7.04	2.83	1.56	37.17
5.			15.9	9.48	2.84	1.82	39.53
6.			12.7	6.18	9.72	8.78	16.44

Figs. 1 and 2 show a notable response to sugar (sugar was added as syrup of the same Brix as that of the molasses), but a still greater response to molasses in both experiments. This is reflected in a greater weight of tops in both, and a much greater weight of roots in the unaerated soil treated with molasses. This effect of molasses and sugar upon the production of roots in this toxic soil is especially significant. There is a notable lack of response to nitrogen, potash and phosphate as compared to nitrogen only, the growth being very poor in the unaerated soil but very good in the aerated soil. Where additional potash is added with sugar to make up for that present in molasses, the response is still less than that obtained with molasses. The response to molasses in the unaerated soil, while better than that obtained without molasses in the aerated soil, is not so great as that obtained with molasses on the aerated soil. It is to be regretted that we did not include in this series a treatment of coral rock with molasses, as we have evidence that the molasses is more effective on this soil type if lime also is added.

The plant analyses show a better assimilation of nitrogen from the aerated soil as compared to the unaerated. While there is some variation in nitrogen in the different treatments, it can not be stated that any of these have greatly affected the nitrogen as per cent dry matter, but of course in amounts of nitrogen actually assimilated, the larger plants, that is, those fertilized with molasses, have assimilated the greater amount. The same is true for the assimilation of potassium and phosphate. In fact, so far as the chemical composition of the plants is concerned, the analyses do not indicate that the relative composition is materially altered by molasses fertilization. The amount of potassium assimilated is especially significant in this connection as just as much potassium has been assimilated from potassium sulphate as from molasses. It is evident from these experiments that the

* Analyses by J. H. Duffy.

potash present in molasses is not the cause of the improved growth on this soil, although this element will be supplied by molasses in an extremely available form.

The toxicity of soils, such as we have used in these experiments, has largely developed from poor aeration, a condition which always accompanies an excess of highly colloidal clay, if associated factors are such as to induce a highly dispersed state. On exposing such soils to the air, to sunlight, or other environment which tends to correct the effect of this lack of aeration, there will follow an improvement in fertility of the soil. Together with this improved fertility, there is an improvement in the physical condition of the soil. The clay will appear less dispersed; will settle more readily when shaken in a column of water, and will, in the field, appear more granular or shotty. One of the principal agents involved in this change in soil property is the carbon dioxide in the air, which, of itself and as basic bicarbonates, is an active flocculant for clay. Accompanying this more desirable physical state is a better availability of plant food and a more active biological flora.

In the fermentation of sugar, copious amounts of carbon dioxide are produced, and we have found that this, like the carbon dioxide of the air, works for a more favorable mechanical state in the soil. This is especially true if there is sufficient calcium in the soil to combine with carbon dioxide to form calcium bicarbonate, which is an active flocculant. Applications of calcium carbonate and molasses to heavy clay soils should be effective if provision is made for proper aeration during the period of active fermentation. Our experiments demonstrate that the effect of molasses is largely reflected in a better root system, and this in turn is the result of an environment created by molasses fermentation, conducive of more active root respiration. The relative composition of the plant is not greatly altered by molasses fertilization as compared to applications of complete fertilizer. It is simply a case of larger amounts of plant food being assimilated through a more active root respiration, and therefore a greater production of plant material. In other words, molasses acts toward the soil in many ways like a fallow, by stimulating nitrification, improving the physical condition and by promoting more active root respiration. The root system must penetrate the soil. Often the soil offers certain difficulties; it may be too dense, too wet or too colloidal. In the latter case the root growth must necessarily be limited to a thin surface area where the roots will have access to air. A normal subaerial growth can only be obtained from normal subterranean growth.

Conclusions

1. Injury following molasses fertilization is due in most part to an increase in the iron and aluminum content of the soil solution as a result of the acid developed during the fermentation of molasses in poorly aerated soil. It would be the better policy to include coral rock or other forms of lime with molasses applications to heavy clay soils, and to plow the field soon after their application so as to obtain good aeration during the process of fermentation.

2. Nitrite nitrogen in the amounts which we have found present in the soil is not toxic toward cane growth.

3. Under field conditions in the soils which we have examined, there has been no evidence of denitrification except where aeration is poor. On the contrary, there has been an active stimulation in nitrification beginning with the period immediately following the application of the molasses.

4. There was no influence upon the availability of phosphate in these soils during the period of the experiments.

5. Potash which is present in molasses is retained by the soil in a very available form.

6. It has been shown by experiments upon Kilauea Plantation soil that molasses reacts very much like a fallow in that it improves the mechanical condition of the soil, stimulates nitrification and root respiration and extends the foraging range of the roots.

Asphaltic Sealing of Reservoirs

A treatise on mainland processes and on a similar development for experimental procedure under Hawaiian conditions.

By F. E. Hance

Methods of reducing seepage in earth-bottom reservoirs have, to a certain extent, been under experiment on Hawaiian plantations for a number of years.

An economic, expedient and satisfactory sealing process has not, as yet, been fully developed.

Observations on reservoirs in some localities have shown that as fine silt, mud or other suspended matter settles from the still waters to the bottom of the basin (and builds up a "cake") the water retaining properties of that particular reservoir become correspondingly better.

On the other hand, a greater number of reservoirs are in use which apparently have not been improved after many years sedimentation has been deposited.

A few reservoirs on the islands of Maui and Hawaii have been serviced in natural basins which were left by extinct volcano craters.

Seepage from this crater type of reservoir is usually very excessive and, as a rule, the waste flow is rapid enough to carry off all residues of fines which would normally collect in an earth bottom basin.

We have numerous reservoirs on each of the Islands which have been built by damming a gulch. The dam may consist of an earth fill, with or without a stone facing, or it may be a plain hydraulic earth-fill structure. Where this type of reservoir has been built in fairly impervious soil and excessive seepage has developed, the trouble has most frequently been located either in the gravel floor of the basin, which was formerly an old stream bed, or it may appear in the artificial dam. This same type of reservoir has also been built on some of the Island plantations in very granular or porous soil. A few of these leaking basins which, obviously, have had to be abandoned and are now lying idle, are put in service only during an unusual emergency.

The problem of leaking reservoirs in the Hawaiian Islands is indeed a very general one and without any doubt a rather serious one.

The correction of seepage has been attempted in past years either by coating the reservoir with a layer of clay-like soil or by puddling the wet and empty basin with cattle driven repeatedly back and forth across the bottom.

In 1927, the department of chemistry at this Experiment Station, investigated the possibilities of a "chemical" or artificial puddling. The material from a number of reservoirs was sampled and experiments were made which showed that certain types of soil were rendered very impermeable by percolating a common salt solution through them. This operation involved a chemical base replacement in the soil colloid. A discussion of the chemistry of the salt treatment was made by

G. R. Stewart and the writer in the *Hawaiian Planters' Record* for October, 1927. In these experiments we found that many of our soils, especially those from Hawaii, did not warrant a salt treatment because of their sandy character or because of a low concentration in colloidal constituents.

A few reservoirs on the island of Oahu were given a salt treatment. One of the smaller basins so treated gave encouraging indications of improvement but the nature of the treatment necessitated the impounding of fresh mountain water, instead of partially saline pump water. This was found necessary because of the likelihood of a reversal of the chemical puddling reactions occurring in the soil from the effect of the compounds in the saline water.

A brief explanation of the manner of securing salt puddling may clarify the above statement:

After a colloidal soil has been saturated with a salt treatment, it will still permit a salty solution to percolate through it at a restricted rate. If, therefore, a supply of fresh water is placed upon this "salted" soil, percolation will gradually be reduced and in some cases it may almost stop entirely. At this point the degree of puddling in the treated soil is at a maximum and the movement of pure water through it under a high hydrostatic head is, as a rule, very slow indeed. However, if a solution of common salt, or a solution of a combination of salts containing some calcium is applied above the treated soil it will gradually cause it to "open up." Water will begin to percolate at an accelerated rate and, in some cases, the original porosity of the soil will be restored.

A large part of our irrigation pump water contains appreciable amounts of common and calcium salts.

If the salt puddling scheme were entirely successful on all our soils (which is not the case) even then the salt treatment could only be utilized for basins designed to store fresh mountain water of very low calcium or sodium content.

As the investigation on puddling progressed it soon became apparent that our soils were so variable and the salt treatment even when applicable was subjected to such a stringent regulation on the character of water to be impounded, that a more practical scheme should be looked for if a satisfactory method of sealing was to be realized.

Early in 1928, the Oahu Sugar Company, Limited, began experimenting with a fuel oil application to the inner exposed surfaces of reservoirs which were badly leaking.

About the same time we began experimenting on small test depressions with a hot coating of Diesel oil containing dissolved petroleum asphalt. The results of the asphalt experimenting were quite satisfactory and later led to the asphaltic treatment at two large basins of the Waimanalo Sugar Company at Waimanalo, Oahu.

An investigation was begun and is now in progress on a characteristic property of asphalt which *may* render it not entirely satisfactory for sealing purposes. In long contact with clay or soil in fine division, under weathering conditions, asphalt becomes as brittle as chalk. This point was brought to the writer's attention by Joel B. Cox, engineer at the McBryde Sugar Company, Eleele, Kauai. Mr. Cox

suggested that the "chalking" of asphalt may prove a serious objection to its utilization for sealing earth reservoirs.

Conferring later with Mr. Stewart, chemist at this Station, a definite research was agreed upon to establish the cause and, if possible, the remedy for the asphalt deterioration. A search of the literature did not reveal a satisfactory explanation of the chalking phenomenon. Mr. Stewart then gave his endorsement to a plan whereby a research would be made to determine:

1. If colloidal adsorption of volatile and plastic constituents of the asphalt took place by contact with soil under alternately wet and dry conditions.

2. If the chalking was the result of the catalytic oxidation of the asphalt induced by contact with impalpably fine Hawaiian soil.

3. If the phenomenon was not but a simple weathering process due to evaporation and oxidation of the asphalt plastics by the sun, rain *and* contact with soil.

We had previously observed that the deterioration of asphalt was arrested in road beds in which crushed stone alone was brought in contact with the petroleum product.

We had also observed at dirt road intersections, and in road shoulder soil overlapping, that asphalt deterioration and road pitting were much more pronounced where the asphalt was in direct contact with the soil. The probable causes of deterioration as suggested in (1) and (2), above, are, we feel, subject to ready control.

A method of primary soil treatment, which is in use on mainland projects, apparently has reduced to a minimum any colloidal adsorption of plastic constituents and has also apparently removed conditions which favor the catalytic oxidation of the asphalt. This primary soil treatment will be discussed later. The matter of evaporation and deterioration by weathering of the asphaltic sealing compound is at present under observation at three locations on experimental installations on the island of Oahu.

In February, 1929, experimental work on asphaltic treatment of reservoirs in Hawaii was postponed while a study was made of mainland practices on similar undertakings. The present schedule of experiment has been modified and expanded as a result of the experiences gained in this investigational study.

The report which follows covers the investigation and carries also a description of the scheme which has since been adopted for experimental work in the Islands.

The Asphalt Association, New York City

Prevost Hubbard, director of the Association, discussed the problems of reservoir sealing with the writer. Mr. Hubbard stated that sealing problems were seldom encountered in the Eastern States. He advocated the continuation of our experimental program but added that he could not contribute any information as to the causes or remedy for asphalt chalking in Hawaii. He gave us several valuable suggestions on canal and ditch lining with asphaltic compounds. These will be discussed under that heading.

Mr. Hubbard offered to supply us with the literature which his Association is publishing and will continue to publish in the future. We are now receiving circulars and bulletins dealing with problems of grouting and sealing with asphalt and road maintenance problems with the same material.

F. E. Schmitt, Editor in Chief, Engineering News Record, N. Y.

Dr. Kirschbraun, Director Research, Flintkoto Co., E. Rutherford, N. J.

Dr. F. H. Rhodes, Professor, Industrial Chemistry, Cornell University, Ithaca, N. Y.

Dr. T. R. Briggs, Professor, Physical Chemistry, Cornell University, Ithaca, N. Y.

The above group of industrial scientists were consulted individually for the purpose of obtaining more detailed information on the composition, manufacture and cost of preparing in Hawaii the water-soluble asphaltic emulsion which has recently become popular on some of our plantations.

This asphaltic emulsion appears on the market in consistency about as heavy as a very thick paint. For use it is diluted with water until a free flowing liquid is obtained. Unlike oil paints, this preparation may be applied to wet wood or metals without the applied coat later peeling from the painted surface. Leaking wood flumes, for instance, may be repaired and painted without the necessity of first drying out the lumber before making the application. The asphaltic emulsion will adhere to and make a very good job of covering on an old water-soaked plank.

After the applied coat has become dry (5 or 6 hours), water thereafter has no more effect on it than it has on any other painted surface which has become dry. For flume work and timber treatment, calling for additions of water or oil soluble toxic chemicals to combat termites and other insects, this type of paint is ideal.

We learned that the compound is made by a patented process. Tar acid and cresolic fractions from by-product coke oven residues are added to naphtha solutions of petroleum asphaltic oils. Partial saponification of the tar acids in the mixture is secured by additions of strong soap (or alkali) and injection of live steam. The mixture then is ready for dilution with water, the product remaining indefinitely in a condition of perfect emulsification.

The preparation of the compound in the Islands would involve some experimentation and perhaps a little difficulty with the patent rights of the manufacturers. Its use has not become extensive enough to warrant any further investigation at this time, although we have the necessary information to begin the experimenting with its preparation.

In May, 1929, the compound could be purchased for 16 cents a gallon in 20-ton lots, f. o. b. New York City, unreturnable steel drums extra.

Asphalt Grouting for Plugging Subterranean Tubes and Fissures in Reservoirs and Dams

We learned from C. A. Bock, vice-president, Morgan Engineering Company, Dayton, Ohio, that hot asphalt grouting had been successfully employed for clos-

ing large underground tubular leaks (lava tubes) in reservoirs situated in former volcanic regions.

We are corresponding with an engineer in Chicago, L. F. Harza, who has had charge of several large undertakings in this type of reservoir sealing.

The scheme has been employed with success against a stiff movement of water through the tubes to be plugged. A simple electric resistance device is used as a part of the delivery equipment which carries the hot asphalt to the channel which it is desired to close.

On one of the Hawaiian plantations a very large reservoir, it appears, has been leaking excessively through underground channels. The district is one where lava tubes may possibly be found.

During the construction of the dam for this reservoir two sump holes developed which carried down a part of the unconsolidated fill. In a short time the downward sinking of earth ceased but the movement may likely be indicative of subterranean tubes or channels. At the present time during periods of low water in the basin, extended longitudinal fissures may be seen in the dam at about the twenty-foot level. The openings in the fissures are, in places, as wide as a man's body. The fissures may or may not be connected with any underground channels. The leakage in this reservoir has been estimated at between ten to twenty million gallons per day. No trace of the leak has ever been found as appearing at the surface of the slopes below the dam.

Considering the history of this structure, a systematic determination of seepage per day at various water levels and a careful and frequent examination of the dam and reservoir may result in the location of the larger leakage channels which apparently are contributing to the existing seepage. Plugging with asphalt or cement might then be accomplished.

We are prepared to furnish information on the manner of applying an asphalt grouting to subterranean channels, should it be desired.

Reservoir Sealing by Asphaltic Treatment

Seepage when found in mainland reservoirs, of earth-bottom and side-wall construction, is usually traced to the dam which impounds the water.

The use of asphaltic compounds as a seal against seepage, at areas in the reservoir other than the dam, is made secondary to the preservative effect that asphaltic oils have upon the water, the inhibiting effect the materials have upon bacteria and to the value of asphalt in weed control from the rim of the basin to the low water level on the banks.

Since most of the mainland catchment projects are designed to impound water for municipal uses, the contamination from fungous growths is sometimes controlled by periodic asphaltic oil treatment on the entire inner and upper basin. Asphalt is said to "sweeten" the water and to inhibit fungus growth.

Weed control is maintained on the slopes and banks of reservoirs by spraying with water emulsion of asphalt oil compounds. The wide use for which heavy asphalt is utilized may, however, be seen in the rip-rapping and sealing against

seepage on earth dams at the very large projects in southern California. The asphalt coating protects the soil in the dam from erosion due to rippling and wave motion and it seals the basin at the point where seepage most usually develops. For the purpose only of sealing against seepage on artificial dams asphalt has been used in California with unquestionable success. In this respect the mainland problems of water storage approximate the conditions we have in the Islands, not only on our dams, but due to our more or less open soils, by preference, on many of our entire basins. A careful study was therefore made of the methods in use by southern California cities in this work.

The reason that a comparatively localized area was selected for a more specific study of asphaltic reservoir treatment was due solely to the fact that the development of the various processes of technic in use there far exceeded the methods of any other known group of cities or of municipal engineers.

The methods employed will be described below and photographs will be shown which illustrate the procedure.

In the early part of this discussion we took up the question of "granulation" of asphalt by its contact with soil. Irrespective of the causes of this deterioration of the asphalt the process is delayed by the California primary reservoir soil treatment which is designed to kill weed and grass seeds. The deterioration process is further delayed after completion of the asphalt sealing operations by an oil spraying at yearly intervals on the banks of the reservoir above low water. The spraying is designed to circumvent the encroachment of weeds and seeds from outside sources.

Before the application of the heavy asphalt oils in a sealing treatment, the moistened soil on the inner surface of the reservoir or dam (or both) is sprayed with a low grade "Diesel" or fuel oil in an amount sufficient to cause a penetration of about 3 inches below the soil surface. One gallon of oil per square yard of surface constitutes a single application. Two applications may be required to secure the 3-inch penetration.

Following the first and successive oil applications the surface of the reservoir is harrowed with a Killifer scarifier. This operation is made in order to bring all plant seeds in contact with the oil, and also to insure and to secure thorough incorporation of oil and soil for the under asphalt foundation.

This primary oil application serves another purpose, we think. It undoubtedly has the effect of retarding the granulation of asphalt which later is placed upon it. We examined treated reservoirs, one 5 years and two 6 years after treatment, which still exhibited a pliable and solid asphaltic coating.

It appears logical to assume then that the primary oil treatment breaks up the soil colloidal influences which tend to granulate the asphalt. Heavy asphaltic treatment is next applied on the scarified soil.

An application of oil containing 40 to 50 per cent asphalt is sprayed on (at 250° F.) at the rate of one gallon per square yard of soil surface.

The soil is again scarified and a final coating of oil containing 90 per cent asphalt is flowed on, one gallon per square yard, at a temperature of 400° F. After the final oil coating a layer of stone screenings, free from dust and passing

Fig. 1. Oiled reservoir, City of Los Angeles.

Fig. 2. Asphalt treatment. Reservoir, City of Los Angeles. General view. Bank on left has had final application.

Fig. 3. Asphalt and oil treatment. Reservoir, City of Los Angeles. After application of "70 per cent" oil.

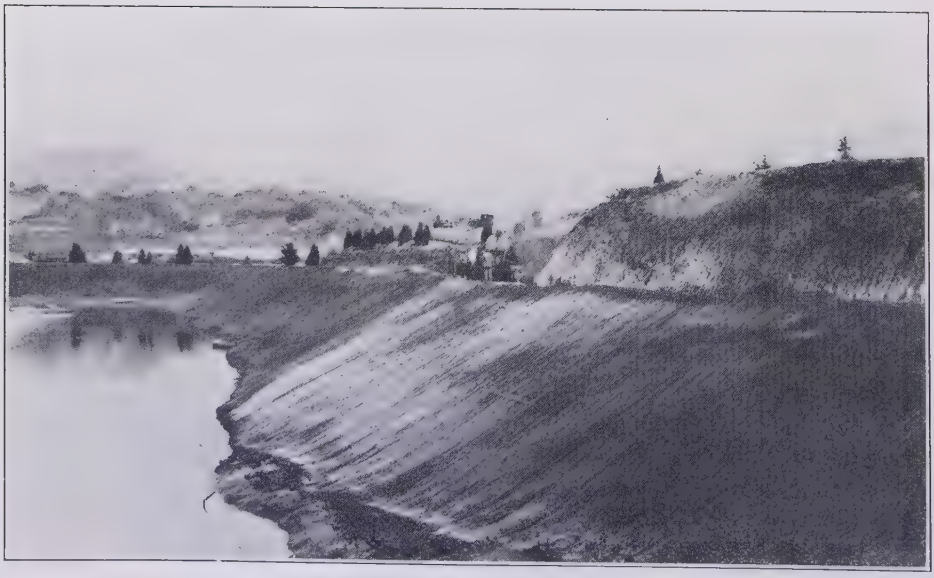

Fig. 4. Asphalt and oil treatment. Reservoir, City of Los Angeles. Appearance of surface after final application of L3 (90-95 per cent) asphaltic oil.

Fig. 5. Asphalt treatment. First step in preparation of surface. Scarified to 3-inch depth by cultivator. Followed by application of 60 per cent asphaltic oil—one gallon per square yard.

Fig. 6. Asphalt treatment. After an application of 60 per cent oil, the surface is scarified and 70 per cent asphaltic oil is applied—one gallon per square yard. The surface is then rolled. (Roller shown in operation.) After rolling, L3 (90-95 per cent) asphaltic oil is applied as a finishing coat.

a ¼-inch screen, is applied at the rate of 2 pounds per square foot of surface. The entire treated area is then rolled with a roller having a weight of 500 pounds per lineal foot of bearing surface.

A finishing coating of the 90 per cent (asphalt) oil is usually applied as a surface dressing. In the Los Angeles District the final surfacing coat is left to the option of the city engineer. It is, however, generally applied. Figs. 1, 2, 3, 4, 5 and 6, with descriptive captions, illustrate the asphaltic sealing operations in California. These prints were supplied through the courtesy of Norman H. Angell, at the San Francisco office of the Standard Oil Company of California.

Mr. Angell kindly made an appointment for the writer by wire with J. F. Jeffries, manager of the Los Angeles office of his company. Mr. Jeffries made arrangements with Messrs. Oliver Lamson, A. C. Craig and B. F. Dupuy for the writer's inspection of several reservoirs in the Los Angeles District as the guest of the Standard Oil Company of California.

Details of asphalt treatment were observed at various stages during the process. Completed jobs were inspected which had been in service up to six years without any subsequent applications of heavy asphaltic oils.

In company with Messrs. A. C. Craig and B. F. Dupuy the following reservoirs were examined for the special features which appear in the brief notes included in the description of each project visited:

Pressure Break Reservoir, Beverly Hills:

Treated by "cultivating" into the soil of the reservoir a 40 per cent asphalt oil at 2 gallons per square yard of surface. After rolling the treatment an additional coating of 90 per cent asphalt oil was applied and rolled. The final applications of heavy oil were about to be applied in June, 1929.

Stone Canyon Reservoir, Above Beverly Hills:

Built with hydraulic-fill dam. Up-stream face of dam covered with solid asphalt. Banks of reservoir were treated by the standard method of asphalt application as described in this paper. Apparently a very effective seal was secured.

Encino Reservoir, Los Angeles:

This reservoir was visited during the period that a supplementary oil application was being applied. The control of weed encroachment and the freshening of the previously applied asphalt coating on the dam and banks were the objectives of the supplementary application. In order to secure a better penetration of oil to the inner fibre of the weeds an aqueous emulsion of two parts water and one part fuel oil was used. The mixture was delivered to the pump which operates the spraying device from a power boat maintained at this reservoir. To prepare the simple emulsion the oil and water were simultaneously delivered from a two-compartment tank to a centrifugal pump in the bow of the boat. An operator on the reservoir bank directed the emulsion discharge from a hose line which was attached to the pump.

Weeds were destroyed by a single application of the emulsion. The asphalt-treated bank was softened and renewed at the same time.

The oil employed in this class of treatment was a thin fuel oil containing about 30 per cent asphalt. The treatment on this basin was made by the standard practice as described under Lippincott specifications.

Lower San Fernando Reservoir, San Fernando, California:

This reservoir has a capacity of 18,000 acre feet of water. It is closed by an hydraulic-fill dam which has remained intact through several severe quakes.

The lower inner face of the dam is paved with concrete blocks. The upper surface has lately been rip-rapped with asphalt to save an undermining of the paving which threatened to become serious. The reservoir proper has received the standard Lippincott asphalt treatment. The banks above low water have received the yearly emulsion treatment which was described under the Encino Project. No trace of weeds or grass was found on any of the treated surfaces. A thick and unbroken coating of flexible asphalt persisted on the dam facing despite the fact that five years had elapsed since the treatment had been applied. An opportunity was found to examine the outside (downstream) facing of the dam at elevations considerably below the water level in the lake.

No seepage was found anywhere in the valley below the dam. Even at points below the floor of the reservoir the dam was dry and powdery and did not support vegetation.

Kenneth Q. Volk, of the firm of J. B. Lippincott, Los Angeles, very kindly supplied us with their specifications for treating reservoirs. A copy of the specifications appears below:

The oil used for asphalt treatment shall be "Gilmore Road Oil" or an oil of equal quality. It shall be applied at a pressure of at least 30 pounds per square inch by a pressure spraying machine which will spread the oil uniformly over the surface. Three applications of oil shall be made and not less than one gallon of oil per square yard of surface shall be used for each application. After each application the surface shall be scarified with a Killifer scarifier so as to secure the maximum penetration. A minimum penetration of 3 inches will be required. For the first application oil containing from 40 to 50 per cent asphalt shall be used. For the second application oil containing from 50 to 60 per cent asphalt shall be applied, at a temperature of not less than 250° F. For the third application oil containing not less than 60 per cent or more than 90 per cent asphalt (the percentage used being subject to the approval of the engineer) shall be applied at a temperature of not less than 400° F.

Before each application of oil the surface of the dam shall be thoroughly sprinkled with water and the oil sprayed on while the ground is still wet. After the final application of oil, a layer of stone screenings which will pass a ¼-inch screen and free from dust shall be spread in sufficient quantity to secure not less than two pounds of screenings per square foot of surface. The whole face of the dam shall then be rolled with a roller having a weight of not less than 500 pounds per lineal foot of bearing surface.

Mastic Ditch Lining

Information on "flexible" ditch coatings with asphaltic bases was difficult to secure from the engineers in charge of the mainland operations which were visited.

The staff of the McGraw-Hill Company and Mr. Hubbard, of the Asphalt Association, both in New York City, gave us information on this topic, however, which we plan to use as a basis of experiment.

The water soluble asphaltic emulsions or low-grade solutions of asphalt in fuel oil are worked into a stiff paste with Portland cement or powdered lime rock.

(The term "plastic cement" as applied to this type of coating was probably given to the mixture because Portland cement was used on the mainland in its preparation. The cement, however, does not function in these mixtures as it does in concrete. It is employed simply as a dispersing medium to check the fluidity of oil or asphaltic base and to act as a filler in the mixture. As a substitute for Portland cement, powdered gypsum or lime rock have been used with equal success.)

The prepared paste is applied by hand to the ditch surface in a layer about 1½ inches thick. In a few days it solidifies into a solid coating of horn-like surface consistency. Rapidly moving water will not tear it from its position, it is claimed.

We propose to carry out experiments in Hawaii in preparing and laying a plastic ditch lining. As a substitute for Portland cement we shall probably attempt to employ a finely powdered coral rock. George Chalmers, Jr., manager of the Waimanalo Sugar Company, has suggested that a very fine sand, which is available on his plantation, may also be used in the ditch lining as a substitute for cement.

The general details of the experimental program on canal and ditch lining have been formulated chiefly on the specifications secured from the Standard Oil Company of California. A copy of the specifications follows:

SPECIFICATION FOR ASPHALTIC CANAL LINING (MASTIC DITCH LINING)

General

Sec. 1. (a) **General Description of Specifications.** This specification covers the construction of an asphaltic canal lining and applies only when the materials used meet the requirements of the standards specified. It is the intent and purpose of this specification to cover specifically the standards of materials to be used and the arrangement thereof in such a manner as to furnish a dense and compacted asphaltic canal lining and to a compacted thickness of one and one-half (1½") inches. This specification does not comprehend the preparation of the subgrade, terms under which this specification is executed, nor anything extraneous to the actual preparation and construction of the asphaltic canal lining.

(b) **Composition of Mixture.** The asphaltic mixture shall consist of approximately 76 per cent sand and approximately 10 per cent mineral filler uniformly mixed and with approximately 14 per cent asphalt and laid to a compacted thickness of one and one-half (1½") inches upon the previously prepared bottom and side slopes of the canal which shall previously be sprinkled with one-half (½) gallon per square yard of two (2) per cent Cresoil. (Cresoil may be obtained through Howard and Beal, 112 Market Street, San Francisco.)

Materials

Sec. 2. **Sand.** (a) The sand for the asphaltic mixture shall consist of hard, uncoated, sharp, durable grains, free from clay, loam or other foreign material.

(b) When tested by means of laboratory screens, the sand shall consist of one or more commercial products and shall pass the openings of a sieve having 10 meshes to the linear inch.

Sec. 3. **Mineral Filler.** The mineral filler shall consist of thoroughly dry limestone dust or Portland cement, free from clay, loam or other foreign materials, and when tested by means of laboratory sieves shall meet the following requirements:

Passing 30 mesh sieve—100 per cent

Passing 200 mesh sieve—not less than 65 per cent

Sec. 4. **Asphalt.** The asphalt used under these specifications shall be Calol Asphalt "D" Grade. It shall be homogeneous, free from water; shall not foam when heated to 175° C. (347° F.). It shall meet the following requirements for physical and chemical properties:

1. **Purity.** It shall be not less than ninety-nine (99) per cent soluble in cold carbon disulphide (CS_2).

2. **Penetration.** The penetration at twenty-five (25) degrees Centigrade (77° F.) 100 g. 5 sec. shall be between the limits of four (4) millimeters and six (6) millimeters.

3. **Ductility.** The ductility at twenty-five (25) degrees Centigrade (77° F.) shall be not less than 100.

4. **Volatility.** The loss on heating at one hundred sixty-three (163) degrees Centigrade (325° F.) for five hours, shall not be more than one per cent Penetration for the residue of twenty-five (25) degrees Centigrade (77° F.) 100 g. 5 sec. shall not be less than fifty (50) per cent of the original penetration.

5. **Flash Point.** The flash point shall not be less than one hundred seventy-five (175) degrees Centigrade (347° F.).

6. **Solubility.** The solubility in cold carbon tetrachloride (CCl_4) shall not be less than ninety-nine (99) per cent.

Sec. 5. **Methods of Testing.** Methods of testing shall be as follows:

(a) **Sand:**

1. Sieve test for sand, Standard Method D7-18, American Society for Testing Materials.

(b) **Mineral Filler:**

2. Sieve test for mineral filler, Standard Method D7-18, American Society for Testing Materials.

(a) **Asphalt:**

1. Solubility in carbon disulphide (CS2) Standard Test, DF-11, American Society for Testing Materials.

2. Penetration, Standard Test D5-16, American Society for Testing Materials.

3. Ductility, Tentative Test D113-21T, American Society for Testing Materials.

4. Volatilization Test. Standard Test D6-20, American Society for Testing Materials.

5. Flash Point (Open Cup). U. S. Dept. of Agriculture, Bulletin 314, page 17.

6. Solubility in carbon tetrachloride (CC14) U. S. Dept. of Agriculture Bulletin 314, page 30.

PREPARATION AND COMPOSITION OF MIXTURE

Sec. 6. **Preparation of Asphalt.** The asphalt shall be heated in kettles or tanks designed to secure uniform heating of the entire contents, and shall be brought to a temperature of 200° F. to 300° F.

Sec. 7. **Preparation of Sand and Mineral Filler.** (a) The sand for the asphaltic mixture shall be thoroughly dried and heated to a temperature of 300 to 350° F. When a

mixture of two or more sands is required in order to produce a material conforming to the requirements of Sec. 8, such combination shall be made either before the sand is fed into the drier or by simultaneously feeding the individual sands into the drier in proper proportions.

(b) The mineral filler for the asphaltic mixture shall be stored separately and shall not be heated with the sand but shall be thoroughly mixed with the sand for from ten (10) to fifteen (15) seconds before the asphalt is added.

Sec. 8. **Preparation and Composition of Asphaltic Mixture.** (a) The sand for the asphaltic mixture shall be measured separately for each batch. The mineral filler shall be added from sacks of definitely known weight. The sand and mineral filler shall be mixed in accordance with the quantities and sizes shown in Sec. 8 (b). The required quantity of hot asphalt for each batch shall be measured by actual weighing with scales attached to the asphalt bucket. The mixture shall be made in an approved mixer by first charging with the sand and the mineral filler, and then adding the asphalt. It is the intent of this specification to provide for thoroughly mixing the sand and mineral filler with asphalt. Such a mixture can be secured in an approved mixer in approximately one (1) minute. Where a homogeneous mixture in which all particles of sand and filler are uniformly coated is obtained in less than one (1) minute, the time of mixing may be varied at the direction of the engineer.

(b) The constituents of the asphaltic mixture shall be combined in such proportions as to produce a mixture conforming to the following composition limits by weight:

Passing a sieve having 10 meshes to the linear inch, retained on a sieve having 10 meshes to the linear inch	20 to 40 per cent
Passing a sieve having 40 meshes to the linear inch, retained on a sieve having 80 meshes to the linear inch	35 to 50 per cent
Passing a sieve having 80 inches to the linear inch, retained on a sieve having 200 meshes to the linear inch	15 to 25 per cent
Passing the 200 mesh sieve	10 to 15 per cent
Asphalt	13 to 15 per cent

The proportions shall be varied within the limits designated as directed by the engineer.

Sec. 9. **Paving Plant Inspection.** The engineer or his authorized representatives shall have access at any time to all parts of the plant for the verification of weights or proportions and character of materials, and determination of temperatures used in the preparation of the mixture.

Sec. 10. **Transportation of Mixture.** The asphaltic mixture shall be transported from the plant to the work in tight conveyances previously cleaned of all foreign materials, and when directed by the engineer, each load shall be covered with canvas or other suitable material of sufficient size to protect it from weather conditions. In case oil is used to prevent the adhesion of the mixture to the bed of the conveyance, an excess of oil shall not be permitted. No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during the daylight unless artificial light satisfactory to the engineer is provided.

CONSTRUCTION

Sec. 11. **Cresoil Application.** A two per cent solution of cresoil shall be applied at the rate of one-half (½) gallon per square yard upon the previously prepared bottom and side slopes of the canal. Sufficient time shall be allowed for the penetration of the cresoil before the application of the asphaltic mixture.

Sec. 12. **Placing Asphaltic Mixture.** Prior to the arrival of the asphaltic mixture on the work the prepared base and sides shall be cleaned of all loose and foreign materials. The mixture shall be delivered at temperature of 275 to 325° F. Upon arrival on the work it shall be at once uniformly spread by means of shovels, forks, or mechanical spreaders in a loose layer and raked to correct depth over the area designated by the engineer. No mixture shall be spread when the base is wet or when weather conditions are unsuitable.

Sec. 13. **Compacting Mixture.** (a) While still hot the asphaltic mixture shall be thoroughly and uniformly compressed with hand roller as approved by the engineer. In rolling the side slopes the rollers shall be drawn up the slope over the loose asphaltic mixture, and no rolling down the slope shall be permitted until the roller has made at least one trip up the slope over the loose asphaltic mixture. Rolling shall continue at right angles to the center line of the canal overlapping on successive trips by at least one-half the width of the roller, until suitable compaction is obtained. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture, and any displacement occurring as the result of the reversing of the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and of fresh mixture when required. The wheels of the roller shall be properly moistened to prevent adhesion of the surface of the mixture to the roller, but an excess of water or other materials for this use shall not be permitted.

(b) Along headers, joints, structures, and places not accessible to the roller, the asphaltic mixture shall be thoroughly compacted with hot tampers to produce sealed joints.

(c) The surface of the mixture after compression shall be true to the established grade. Any mixture which during construction becomes loose or broken and mixed with dirt or in any way defective shall be immediately remedied by removing the asphaltic mixture at such spots and by replacing it with hot fresh asphaltic mixture, which shall be immediately compacted to conform with the surrounding area.

Sec. 14. **Joints in Surface Course.** The placing of the asphaltic mixture shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying is to be discontinued for such a length of time as to permit the mixture to become chilled. In such cases provision shall be made for proper bond with new asphaltic mixture by cutting or trimming back the joint while the material is still hot, so as to expose an unsealed or granular surface for the full specified depth of the mixture. At the end of each day's work, joint shall be formed by laying and rolling against boards of the thickness of the compacted mixture, or by such other methods as may be approved by the engineer. When the laying of the asphaltic lining is resumed, the exposed edge of the **u** joint shall be painted with a thin coat of hot asphalt and fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers and rolled. Hot smoothing irons may be used for sealing joints, but in such cases extreme care should be exercised to avoid overheating the surface. In cases where joints are made between the asphaltic mixture and other structures or linings, the exposed edge of these structures or linings shall be painted as specified above.

Sec. 15. **Protection of Lining.** Where the transverse edge of the asphaltic lining does not terminate against other structures or linings, this edge shall be curved and buried to a depth of one foot below the surface of the lining. Sections of newly compacted asphaltic lining shall be protected for at least six hours, or until the asphaltic mixture has become properly hardened by cooling.

Gumming Disease of Sugar Cane

By J. P. Martin

Under the guidance of D. S. North, pathologist, Colonial Sugar Refining Company, Ltd., Sydney, and A. F. Bell, pathologist, Bureau of Sugar Experiment Stations, Department of Agriculture, Brisbane, the writer had an opportunity, during 1929, to study the diseases of sugar cane occurring in Australia. It was possible to observe the major cane diseases such as gumming, leaf scald, Fiji disease, and downy mildew under field conditions and also to become familiar with their diagnostic symptoms. Many of the minor cane diseases also were noted and studied in the fields visited both in Queensland and in New South Wales.

Gumming disease is considered one of the oldest diseases affecting sugar cane and has often been a subject for discussion in the literature. The object of this paper is to discuss gumming disease in detail presenting the geographic distribution and history of the disease, the diagnostic symptoms used in recognizing the disease and the measures now employed for its control.

Gumming disease was much more severe in New South Wales than in Queensland; in fact, all studies conducted on the disease were carried out in New South Wales in association with Mr. North, to whom we are indebted for our recent knowledge on the transmission of the disease. To mention a specific example of the seriousness of gumming, Mr. North pointed out that the disease started in the cane fields in the Richmond River district about 1919. During the next four or five years severe crop losses resulted and it was quickly learned that such desirable commercial varieties as Badila, Mahona and M 1900 could not be cultivated profitably because of their susceptibility to the disease. These susceptible varieties were replaced with inferior commercial varieties, such as Malabar (Yellow Caledonia) and H. Q. 5. The disease has been greatly reduced through the substitution of resistant varieties. A loss in sugar per acre followed the substitution, and North (16) has stated, "Every individual grower is contributing a large portion of his income annually in the shape of diminished crop returns from the inferior but resistant varieties." The cane growers in New South Wales are permitted to plant only approved canes, a list of which is published at intervals by the Colonial Sugar Refining Company, Ltd. This list includes those commercial varieties that are resistant to specific diseases in the different districts. A cane variety may be planted in one locality but not in another simply because gumming may not be a problem in one district, while it is a serious problem in another. This rigid system is largely responsible for the present control of cane diseases in New South Wales and the growers fully appreciate the merits of the system.

Prior to 1912, gumming disease was a serious menace in Fiji, according to Mr. North, but with the adoption of certain definite control measures the disease has rarely been observed since that time even though susceptible varieties are still being grown.

Geographic Distribution and History

According to the literature gumming disease now occurs in the following sugar cane countries: Brazil, Mauritius, Australia, Fiji, St. Kitts, Porto Rico, St. Lucia, Colombia and Guadeloupe. It has also been reported as occurring in Java, Borneo, New Guinea and Argentina by the late Erwin F. Smith but confirming evidence regarding its presence in these countries is lacking.

In Java, and probably Borneo, the disease once thought to be gumming has been definitely shown by Wilbrink (20) to be leaf scald disease. Leaf scald disease is known in Java as "Gomziekte" and for many years there existed a great deal of confusion regarding the identity of leaf scald or gomziekte and the Australian gumming disease. Both North (13) and Wilbrink (20) have shown that these diseases are distinct. The present status is that the Java gumming disease as described by Wilbrink is identical to that of leaf scald disease which has been described independently by North (13) in Australia. Australian gumming disease is not known to exist in Java.

Many varieties of *Saccharum officinarum* are affected with the disease. Two varieties of *S. sinense* have proved susceptible to artificial inoculations. The earliest record indicates that the disease originated in South America, but since sugar cane is not indigenous to that country, it is maintained by some investigators that the original host may have been one of the large grasses of South America

Gumming disease has been reported under the following names: Cobb's disease of sugar cane, Gummosis, Gomosis, maladie de la gomme, and gum disease. The first authentic record of the disease was by Dranert, in 1869, whose observations were made in the sugar region of the province of Bahia, Brazil. Dranert (9) stated that the disease had been epidemic for the preceding six years and that it had been recognized as a distinct disease for a much longer period. The disease was finally controlled by replacing the variety Otaheite with Cavengirie which is not immune but is highly resistant. Dranert (9) was the first investigator to find and associate bacteria as the causal agent of the disease. He observed bacteria in the gum or exudate and considered these organisms to be the cause of the disease. The following is a translation by Erwin F. Smith (18) of a portion of Dranert's work:

> On the contrary, as an infallible sign of the disease there appears in the first place a red stain in the wood and the surrounding cambium tissue of the nodes. As the disease progresses this stain spreads in the same bundles through the whole shaft of the cane, while the parenchyma for a time retains its natural clearness. In the fully developed disease a yellow, thick fluid substance flows out of the bundles. This substance hardens in the air, but dissolves in water, and under the microscope, with very high magnifications, is seen to have only a granular structure. When dissolved in water one can make out very minute cells lying in amorphous heaps, or attached to each other in necklace fashion.

There is no question but that the Brazilian disease studied by Dranert was the same disease subsequently described in Australia by Cobb (7).

Cobb (6) observed the disease in 1893, in the Clarence River district and also in the Richmond River district in New South Wales. According to his observations at that time gumming was very prevalent and serious crop losses occurred.

Cobb was able to trace the first appearance of the disease to 1876 in the Lower Clarence River district; and he also reported the occurrence of the disease in Queensland, 1893. In 1895, Tryon (19) talked with a number of persons who recalled having seen the malady two years earlier, one of whom having seen it as early as 1884, in a cane variety known as Rappoe in Queensland.

The first authentic detailed description of the disease and the identification of the causal organism was by Cobb (6). He named the disease "gumming of sugar cane" and the organism *Bacterium vascularum*. He did not use pure cultures in reproducing the disease but his inoculations were direct, that is, healthy canes were inoculated with the fresh gum taken from the ends of freshly cut vascular bundles under aseptic conditions. Cobb's studies on this disease have served as a basis for subsequent descriptions and his conclusions regarding the aetiology of the disease were later confirmed by Greig-Smith (10) and Erwin F. Smith (17). Cobb failed to observe and describe the streaks on the leaves as a symptom of the disease.

Boname (4), in 1894, reported Cobb's gumming disease as common in Mauritius on a variety called La Canne Bambou (Bamboo cane), and considered it to be their most serious local cane disease. A correspondent of *Sugar Cane* (1) in 1894, at Pernambuco, Brazil, described a serious disease of cane and from his descriptions it appears that the unknown disease was undoubtedly gumming. He described the formation of gum, the discolored vascular bundles, the early drying of the leaf tips followed by the premature death of the cane; the canes which did not die failed to yield ratoons and the juice of diseased canes was extremely difficult to crystallize. The nature of this disease was not explained and the varieties attacked had been under cultivation for many years. The two varieties, Otaheite and Creole were highly susceptible and the correspondent advanced the theory that these varieties were "running out." Others were of the opinion that the condition was due to depleted soil, but these varieties even failed on rich virgin soil. Since no cure of the disease could be found these two varieties were discarded, and replaced with introduced varieties of foreign origin. The new canes were not attacked and this particular case is one instance where an unknown disease was controlled by substituting what proved to be resistant varieties for the susceptible ones without knowing the nature of the trouble.

Greig-Smith (10), in 1902, published a paper in Australia on "Gummosis" of sugar cane. He isolated the pathogen and described its growth on various culture media. From his studies he concluded that the gum in diseased canes was of bacterial origin and not a secretion of the host plant. The gum produced on the surface of cane-gelatin or agar media was identical with that found on freshly cut surfaces of affected stalks.

In 1904, Smith (17) published the results of his carefully planned experiments with gumming disease. He used pure cultures for his inoculation studies which were conducted in the greenhouse at Washington, D. C. He stated that he had never seen the disease in the field. His conclusions verified the fact that *Bacterium vascularum* (Cobb) Greig-Smith, was the causal organism and fully confirmed the results of the work of previous investigators.

Cobb's (8) third report, which appeared in 1905, on gumming of sugar cane

merely restates the findings of Smith, Greig-Smith and his own determinations in relation to the disease.

In 1914, Smith (18) fully reviewed the early literature on the subject and described his previous investigations, these having been carried out much further since 1904. Most of our exact knowledge of the disease is due to the outstanding work of Smith.

As stated above the disease was first reported in Brazil, then in Mauritius and later in Australia. From studying the early records regarding the spread of the disease it is quite evident that the disease was carried from country to country in cane cuttings. In 1869, a shipment of cuttings was sent from Brazil to Mauritius and in all probability some of these cuttings were taken from cane districts where gumming disease existed since the disease appeared in Mauritius the following year. The disease made its way from Australia to Fiji through cuttings due to the free interchange of canes at that time. This information merely points out the ease with which the disease may be spread through the importation of foreign canes.

The disease was identified by Matz (11) in Porto Rico, February, 1920. He pointed out that the disease may have existed to a limited extent the previous year.

Ashby (2) reported that the disease was first noted in 1925 in St. Kitts and St. Lucia, British West Indies.

Chardon and Toro (5) found the disease present in Colombia in 1926 and they considered it to have been prevalent there for many years. It had probably been introduced from Brazil, where it was a serious malady as early as 1869.

Williams (21) reported that a survey made March, 1929, showed that the cane variety Ba. 11569 on plantations in Guadeloupe was generally affected with gumming disease and that this was the first record of its occurrence in the island.

Description

Smith (18) presents a concise description of gumming disease, as follows:

> The most conspicuous signs of this disease are dwarfing, striping of the leaves, dying of the tops, decay of the heart (terminal bud), and the appearance of a yellow slime or gum in the bundles of the stem and leaves. Many of the bundles are also stained red. Microscopic examination shows that this gum contains millions of bacteria. Cobb and Boname agree that there is also a reduction of the sugar content.
>
> The disease is primarily one of the vascular system but in advanced stages the parenchyma is attacked, especially the soft tissues just below the terminal bud, and cavities are formed which are filled with the yellow bacterial slime. Sometimes these cavities contain as much as a teaspoonful of the slime. In the later stages of the disease, the interior of the leaf sheaths is rusty brown and covered with the sticky bacterial slime, which is also sometimes seen oozing from other portions of the leaf. This slime oozes from the stomata.

The appearance of the leaf streaks is the most useful symptom in detecting the earliest stages of the disease in the field. These symptoms are readily recognized on the young plants affected with the disease. The disease is confined to the older leaves and the symptoms seldom occur on the five youngest leaves. The streaks

are yellowish in color, often containing reddish-brown spots or blotches, varying from ⅛ to 3/16 inch in width, while their lengths vary with their age and development. The streaks are frequently one-half the length of the leaf. The streaks may develop any place on the leaf depending upon where the primary infection takes place, traveling both upwards and downwards in a well-defined line following the course of the vascular bundles. The affected tissue in the older streaks becomes brown or ashy in color and ⅛ to ½ inch wide. The streaks taper off at each end and become a yellow or yellowish brown color. Occasionally the streaks appear on the upper half of the cane leaf and run out at the leaf tips or margins. Such streaks are more pronounced on leaves of susceptible canes following periods of wet weather but may disappear almost entirely during periods of dry weather. Several streaks may develop on the same leaf and in badly affected fields the cane has a dried appearance due to the amount of dead tissue at the tips of the leaves.

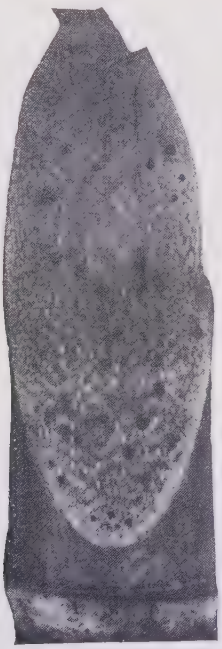

Fig. 1. Exudation of gum on freshly cut surface of diseased stalk. Broadwater, N. S. W. (Photo by J. P. Martin.)

Gumming disease when confined to the leaves does not cause the losses which occur when the disease travels down the leaf blade, through the leaf sheath and into the growing stem; this condition is known as the systemic form of the disease. Stalk infection or systemic development varies with the variety and the growing conditions of the cane. In case the leaf symptoms disappear no external signs are present and the stalk may harbor the disease for 12 to 18 months. In such cases a cane may appear healthy, although it is diseased and plants grown from cuttings from such stalks may develop the disease.

The systemic form may slightly depress the growth of the young cane while in old stalks the stunting of the growth is much more severe, the leaves become narrow, and the stalk in time becomes noticeably shortened or tapered toward the growing point. Following systemic infection the tops may die and a top rot may result.

The outstanding diagnostic symptom of systemic gumming disease is the exudation of a yellowish to orange-red slime that quickly forms on the surface of freshly cut ends of affected stalks as shown in Fig. 1. Excellent colored plates showing gum exuding on cut ends of affected stalks were published by Cobb (8) in 1905. Another excellent colored plate showing the presence of the streaks on the leaves, lysigenous cavities in the stalk and the beads of gum exuding on the cut ends of an affected stalk appears in a publication by Bell (3) in 1929. With stalks slightly affected the test for gumming is made by immediately placing fresh cuttings in a vasculum, or closed container, thus subjecting it to a high humidity for 30 to 60 minutes. At the end of this period small beads of gum may be observed on the cut ends. Gum frequently may be obtained from affected leaves by subjecting them to the "sweating" process. If a container is not available in the field to make the test for the presence of gum, a small piece of cane stalk may be placed inside of one's hat which is then replaced on the head for a short time.

If no gum forms from the "sweating" treatment and no red bundles are visible and a variety is still under suspicion a more complete test may be made by planting cuttings from suspected stalks. After 4 or 5 weeks these cuttings are removed from the soil and all discolored tissue carefully cut away. The cuttings are then cut into several short pieces and subjected to the "sweating" treatment. If no exudation of gum appears with this treatment, one may feel satisfied that the original canes were free from the disease.

The gum when examined under the microscope, is found to contain myriads of rod-shaped bacteria. As mentioned before, the gum is formed by the countless numbers of bacteria and is not secreted by the host plant. The bacteria frequently invade the parenchyma tissue near the growing point and cause a rapid breaking down of the tissues giving rise to lysigenous cavities or "gum pockets." When affected stalks are split longitudinally these "gum pockets" are found to vary considerably in size. The cavities are filled with a gummy mass and often such pockets contain practically pure cultures of the organism. In later stages of the disease the tissues of the leaf sheaths frequently become a rusty brown color and are covered with the sticky bacterial slime.

The gum is soluble in water, but insoluble in alcohol; Cobb (8) refers to it as, "a yellowish, non-crystalline, viscid substance having an almost imperceptible acid reaction."

Tissues Affected

The presence of the disease in the stalks is manifested by reddened vascular bundles, especially at the nodes. The disease is largely confined to the vascular system, the vessels of the xylem gradually becoming filled with the bacteria. (See Figs 2, 3, 4 and 5.) The phloem is less frequently affected. The development of

the organism in the plants results in a clogging of the conducting tissues, the normal functions of such tissues being greatly impaired.

Description of the Causal Organism

Erwin F. Smith and others have very carefully described the causal organism. *Bacterium vascularum* is a short rod, 0.4 x 1-1.5 microns, motile, with a single flagellum; no spores have been observed; it is gram positive (but difficult to stain);

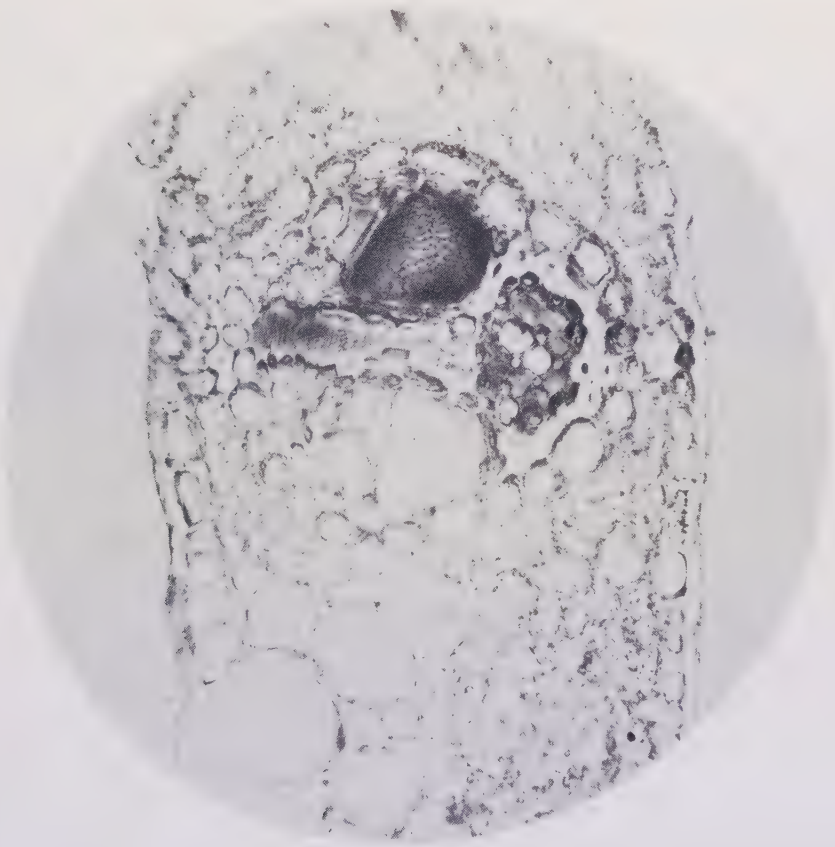

Fig. 2. Cross-section of cane leaf affected with gumming, showing bacteria and gum in both xylem and phloem x 370. (Photomicrograph by D. M. Weller.)

pseudo-zoogloeae are formed. It is readily cultured on most nutrient agars. When grown on standard nutrient agar the colonies are pale yellow, smooth, and shining. The organism is strictly aerobic so far as known; optimum temperature, 30° C.; growth retarded at 35° C.; thermal death point 49-50° C. It does not form gas, forms no acid, does not reduce cane sugar and does not reduce nitrates to nitrites.

Transmission

North, in recent studies yet unpublished, has shown the ready transmission of the organism from plant to plant during wet weather, especially if accompanied by winds. Wind causes a considerable amount of mechanical injury to cane foliage due to the serrate edge of one leaf coming in contact with the flat surface of another leaf. During wet weather the gum or exudate oozes freely from diseased foliage and is transferred from leaf to leaf, and stool to stool principally by leaf contacts. The organism gains entrance through the fresh wounds. The organism is unable to penetrate the normal or uninjured cuticle of the leaf and seldom enters

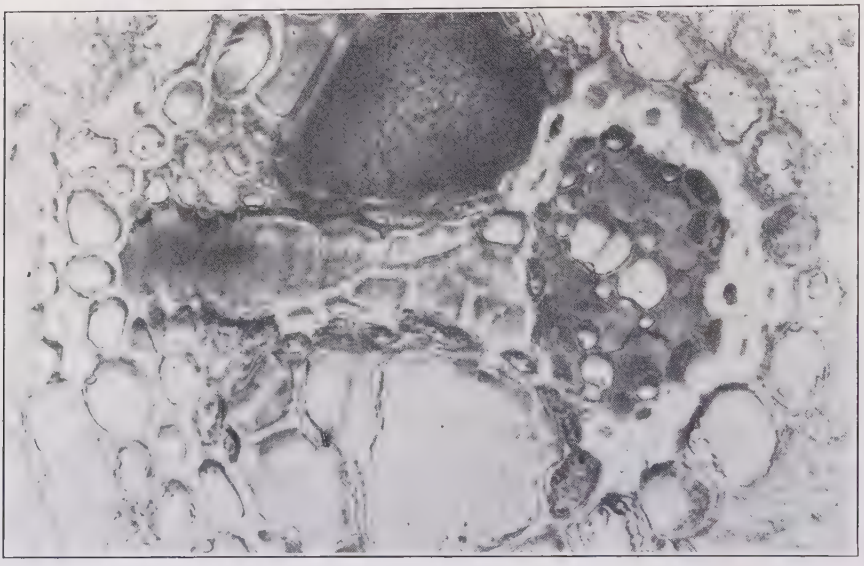

Fig. 3. An enlargement of the bundle shown in Fig. 2, showing in greater detail the discoloration of xylem and phloem due to the occlusion of these tissues by the gum and masses of bacteria, x 565. (Photomicrograph by D. M. Weller.)

through old wounds. Typical leaf streaks may be observed some two to four weeks after infection. The presence of moisture on the leaves is essential for the spread and development of the disease. Heavy dews, which often occur during comparatively dry weather, are responsible for a certain amount of spread of the disease.

North has concluded that sucking cane insects are not important in general as agents of transmission, although they may occasionally act as mechanical carriers and may carry the disease for long distances.

The bacteria may be carried by farm implements, especially on cane knives and since the organism is moderately resistant to desiccation it is very probable that the disease is carried from field to field in this fashion.

Control of the Disease

Like all bacterial diseases, gumming presents a complex problem and few control measures, other than resistant varieties, have proved effective. Farm imple-

ments, cane knives, etc., may be treated with an effective disinfectant solution, or exposed to the direct sunlight for short periods before being taken to healthy fields. Roguing is impractical owing to masking of the symptoms. Individual stalks for examination in the fields should be broken off instead of being cut from the stool; this prevents the spread of the disease by knife infection as the same knife may be used during the next five minutes on a healthy stalk which may become inoculated. Preventing the movement of laborers and animals from field to field during wet weather may lessen the spread of the disease. Both in Queensland and New

Fig. 4. Longitudinal section of an infected bundle, showing the disorganization of the tissues and the beginning of a lysigenous cavity at x. x 370. (Photomicrograph by D. M. Weller.)

South Wales the disease is less severe on well-drained land than on poorly drained areas.

The greatest success in controlling the disease has been obtained by the use of resistant varieties. A slight reduction in yield may result should the resistant variety be commercially inferior to the susceptible varieties, but when it is possible to have a loss of 60 per cent or more from the disease this reduction is not so serious; the surrounding fields of susceptible canes are also protected.

Since resistant varieties may be diseased and yet exhibit no external symptoms of gumming, it becomes essential to subject all introduced canes, upon their arrival, to contact planting with susceptible commercial canes of the importing country. Such tests should be conducted only under strict quarantine. Since the immersion of diseased cuttings in hot water for one hour at 52° C. results in the death of the organism, the hot water treatment of cane cuttings practically assures the elimination of the disease. The advantage of subjecting imported canes to such a precautionary treatment is self-evident.

Fig. 5. Longitudinal section of cane leaf affected with gumming disease, showing the breaking down or disintegration of the tissue in the xylem. x 565. (Photomicrograph by D. M. Weller.)

Cane Varieties in Relation to Gumming

Under the direction of Mr. North the new cane varieties, in some localities, are often planted in bad gumming areas and within one season the highly resistant ones to the diseases are easily selected, as shown in Figs. 6, 7 and 8. Only the very resistant varieties are tested for their agricultural value. Several of such gumming test plots were visited. In some cases all the plants of a susceptible variety were killed outright while adjacent resistant varieties remained healthy.

Fig. 6. Cane varieties in relation to gumming disease, showing a susceptible variety (left) as compared to a resistant variety (right). Broadwater, N. S. W. (Photo by J. P. Martin.)

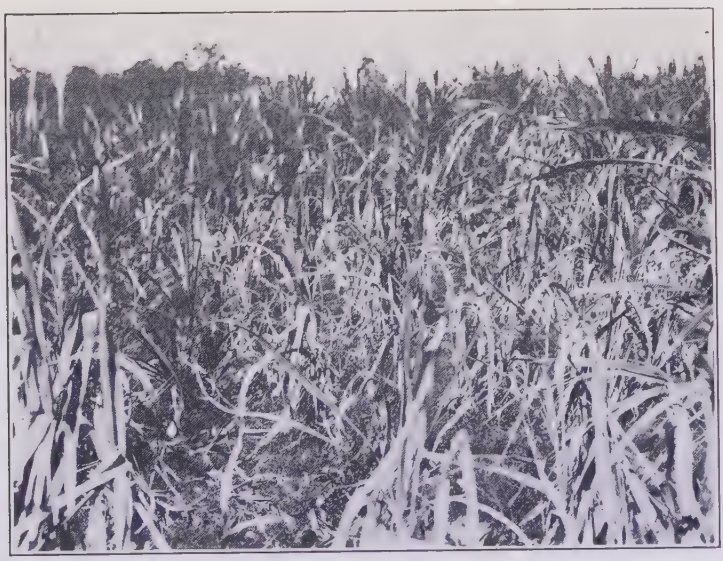

Fig. 7. A susceptible variety badly attacked with gumming disease showing scarcity of healthy leaves and sparse growth. Broadwater, N. S. W. (Photo by J. P. Martin.)

Fig. 8. Testing new varieties for gumming resistance. The variety in the foreground has been completely killed, while the variety in the background shows a high degree of resistance to the disease. Broadwater, N. S. W. (Photo by J. P. Martin.)

The following is a list of canes classified according to their resistance to gumming disease which was compiled by Mr. North:

Highly Resistant	Moderately or Commercially Resistant	Susceptible
H. Q. 5	Innis 131	Rose Bamboo
Q. 813	N. G. 16	D. Dupont
Malabar (Yel. Cal.)	D 1135	Lahaina
N. G. 14	Badila	H 109
Korpi	Mahona	
Oramboo	M 1900	
Nanemo or Bogela		
H 227		
China		
Uba		

Summary

1. Gumming disease is considered one of the oldest maladies affecting sugar cane. Severe losses have resulted from its introduction into countries growing commercial varieties that have proved susceptible.

2. Through the importation of diseased cuttings the disease has been spread from one cane country to another. It was first recognized in Brazil in 1869 and now occurs in nine different sugar cane countries of the world.

3. The dwarfing of the plants, striping of the leaves, dying of the tops, reddish bundles in the stalk and the appearance of a yellowish slime or gum on freshly cut surfaces of affected stalks are the conspicuous symptoms of the disease.

4. The gum or exudate is formed by the bacteria and is not a secretion of the host plant. The gum is sticky, soluble in water and is found to contain innumerable rod-shaped bacteria.

5. The transmission of the organism occurs mainly during the wet season and spreads largely by leaf contacts. The organism gains entrance only through fresh wounds. Leaf wounds are formed commonly during wind storms. The presence of moisture on the leaves is necessary for infection of the host and development of the disease.

6. North has concluded that sucking insects are not important as specific agents of transmission although they act as mechanical carriers and may transport the organism for long distances. The bacteria may also be carried on farm implements, cane knives, and animals.

7. New cane varieties should be tested as soon as possible in order to determine their resistance to the disease.

8. The most effective control has been secured through the substitution of resistant varieties. Disinfection of cane knives and implements is also recommended. The immersion of diseased cuttings in hot water for one hour at 52° C. is very effective in killing the organisms. Such a treatment given to all newly imported cane cuttings would largely eliminate the chances of introducing the disease into a country.

Acknowledgments

The writer wishes to express his appreciation for the information so kindly furnished by Mr. North relative to gumming disease. The writer herewith also expresses his appreciation to both Messrs. North and Bell for pointing out the salient facts regarding gumming and other cane diseases occurring in Australia.

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Iron Sulphate Spray for Coral Chlorosis

EWA PLANTATION COMPANY
EXPERIMENT 1, 1929 CROP

By R. E. Doty

This experiment was conducted cooperatively by the Ewa Plantation Company and the Experiment Station, H. S. P. A. This test was in Field 9A, situated in a bad coral area. The layout consisted of eleven watercourse plots of irregular size.

This experiment was harvested previously, for the 1928 crop, and reported by J. A. Verret in the *Planters' Record,* Vol. XXXII, pp. 180-182 (April, 1928).

A review of the results of the previous crop is given herewith.

The 1928 crop received one spraynig with a 5 per cent solution of iron sulphate at three months of age. It was harvested on January 6, 1928, at the age of 21.5 months with the following yields:

Yields—1928 Crop	Arith. Average—Adjacent Plots		
	Cane	Q. R.	Sugar
Iron spray	84.12	9.99	8.42
No spray (base)	73.11	9.97	7.33
Gain or loss for sprayed plots	+11.01	—0.02	+ 1.03
Per cent gain or loss for sprayed plots	+15.06	—0.20	+14.87

A 15 per cent gain is noted in favor of the sprayed plots.

The short ratoons harvested in 1929 show a much greater gain (35 per cent), as is given in detail in this report.

The cane was H 109, second ratoons, short, and was 17.4 months old when harvested on June 18, 1929. The crop was started on January 6, 1928. It received two sprayings with a 5 per cent solution of iron sulphate, the first on February 10, 1928, at the age of 1.13 months and the second on March 16, 1928, at the age of 2.3 months.

The labor for the first spraying was at the rate of 0.455 man day per acre and the iron sulphate cost 20 cents per acre.

The second spraying took twice as long and used twice as much material. Total cost of the two sprayings amounted to about $3.00 per acre.

Observations and photographs made on May 10, 1929, showed a marked contrast between the spray and no-spray plots. The stand was good in the sprayed plots and almost a failure in much of the unsprayed area. This effect is the result of saving the stand in the previous crop as well as in the second ratoons. The effect has been decidedly cumulative. The normal plantation replanting was carried out irrespective of treatment but did little for the unsprayed plots. (See Figs. 1 and 2.)

Fig. 1. Iron sulphate spray vs. no spray on young ratoon cane affected with lime-induced chlorosis.

Foreground—No spray.

Background—Sprayed twice with 5 per cent solution of iron sulphate.

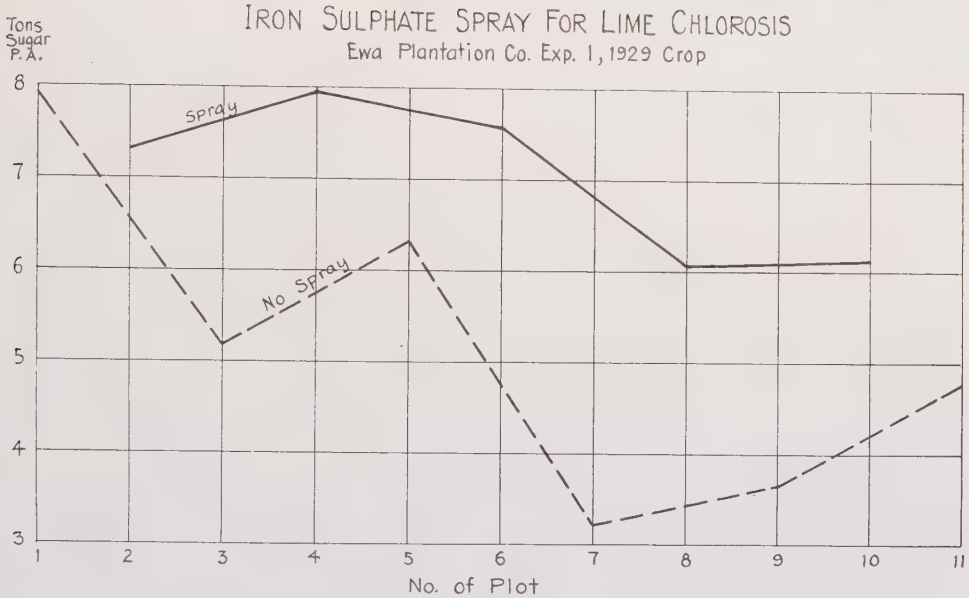

Fig. 2

Ewa Plantation Company computed the results of the 1929 harvest as follows:

SUMMARY OF HARVESTING RESULTS—YIELDS PER ACRE

Treatment	(Arithmetical Average) Cane	Q. R.	Sugar
S—Iron sulphate spray	56.83	8.13	6.99
X—No spray	42.23	8.15	5.18
Gain or loss for sprayed plots	+14.60	+0.02	+ 1.81
Per cent gain or loss for sprayed plots	+34.57	+0.25	+34.94

PLOT TO PLOT COMPARISON

	Total	For S Plots	Same	For X Plots	Odds	Mean Difference Student's Method
Cane	9	8	0	1	1043.4 :1	+15.85
Quality ratio	9	2	4	3	1.77:1	+ 0.03
Sugar	9	2	0	1	832.0 :1	+ 1.97

NITROGEN RATE OF APPLICATION (field application)

	1.83 Mos. Mar. 6/28	3.97 Mos. May 10/28	6.10 Mos. July 14/28	Total Lbs. N.
All plots	53	76	106	235

There is a consistent gain averaging 14½ tons per acre of cane for the treated plots. A biometric analysis by Student's method gives odds of 1043 to 1 against a difference of 15.85 tons of cane being due to chance.

In quality ratio there is no consistent difference between treated and check plots.

The treated plots show an average gain of 1.8 tons of sugar per acre, or a 34.9 per cent gain over checks.

This evidence is quite conclusive that the use of iron sulphate applications in this coral area is warranted and should be employed extensively.

Applications can be made on a field scale at a very low cost per acre compared to the value of the results which accrue.

Notes on Pythium Root Rot

VI

By C. W. Carpenter

Several experiments, in continuation of those cited in "Notes on *Pythium* Root Rot, V"* are discussed in this paper. To recapitulate, root rot of the sensitive Lahaina variety was greatly increased by amending "healthy" soil with stable manure and molashcake. An experiment was mentioned wherein an unsuccessful attempt was made to induce root rot of H 109 by the use of amendments of cane compost. H 109 and Lahaina, as well, grew luxuriantly without root rot in compost alone; Lahaina developed serious root rot, however, in half-and-half mixtures of soil and compost while H 109 had a healthy root system in this as in all mixtures from 20 to 90 per cent compost by volume. It was also mentioned that molashcake amendments greatly aggravated *Pythium* root rot of Lahaina in "sick" Waipio soil, and induced serious root rot of Lahaina in healthy Makiki soil.

It was inferred that Lahaina roots rotted conspicuously when growth was stimulated by amendments of certain materials. H 109 differed from Lahaina in that growth could be greatly stimulated without the occurrence of *Pythium* root rot. The investigation of this point was carried to an extreme in Experiment 112, discussed below, wherein H 109 was grown in pots with soil amended with stable manure.

Experiment No. 112—Effect of Stable Manure on H 109

Sixteen 12-inch pots were prepared with pathology plot soil and stable manure amendments in various amounts by volume as shown in Table I. Cuttings of H 109 were planted November 24, 1928. On February 26, 1929, observations were made and the roots of one plant of each series were washed for examination.

TABLE I

Pot No.	Amendment	Root Rot Feb. 26th (Age 3 Months)	Root Rot May 28th (Age 6 Months)
1-4	Controls	None	None
5-8	25 per cent manure	Moderate	None
9-12	50 per cent manure	Serious	Slight
13-16	75 per cent manure	Serious	Moderate

Appearance of Plants: Control plants were rather pale and restricted in growth, apparently needing more plant food than the unfertilized soil supplied. The plants in the manure amendments were dark green in color, and of larger

* *Hawaiian Planters' Record*, Vol. XXXIII, No. 2, April, 1929, p. 155.

size, except for those in the 75 per cent amendments, which were about the size of the controls. In those soils with larger manure amendments leaf burn and firing of the lower leaves were prevalent.

Root Observations at Three Months. Pot No. 1 Control: The root mass appeared normal for the size of the plant and was characterized by a good development of secondary and tertiary roots and small rootlets. The roots were in general of the fine and wiry type with no large or stimulated roots, such as are common in rich soils.

No. 5. Twenty-five Per Cent Manure: This plant had the largest root mass of the series, characterized by many large, white primary roots, which were mostly healthy. Compared with the control, there were few secondary and tertiary branches, and fine rootlets. A considerable number of the large white roots showed *Pythium* root rot lesions, i. e., yellow to red cankered areas and root tips, many of the latter being flaccid.

No. 9. Fifty Per Cent Manure: Nearly the same root mass was noted as in No. 5, but there was more evidence of *Pythium* injury. Forced branching of the primaries was common following *Pythium* rot of the tips of these roots.

No. 13. Seventy-five Per Cent Manure: Large white primaries were present as in Nos. 5 and 9, but not nearly as numerous. The total root mass was much reduced. Forced branching with large secondaries was common. There were very few small, fine rootlets. *Pythium* rotting of the larger roots with red discoloration was a conspicuous feature, with a flaccid condition of root tips very common on roots of all sizes.

Another series was washed a month later with improved conditions of root health being noticed. The pots were in the open and subject to leaching from rains. On May 28, all remaining units were washed.

Observations: Controls: No. 3; small top as if starving; no stooling; no root rot. No. 4; larger top, with fair green color; two new shoots starting; no root rot.

No. 8. Twenty-five Per Cent Manure: Top much larger than controls, with darker green color, and abundant stooling. Root mass large and filling the pot; no root rot.

Nos. 10 and 12. Fifty Per Cent Manure: The tops were large and green, with good stooling. Roots not quite as well developed as in No. 8 and some showed *Pythium* root rot.

Nos. 15 and 16. Seventy-five Per Cent Manure: The tops were about the same as those of Nos. 10 and 12. There was less stooling than in the 50 per cent manure. Not much of the original root system remained, but there was a predominance of new root growth with some root rot in evidence. These pots seemingly retained enough of the plant food from the manure to stimulate growth, as evidenced by the large white roots, though these latter were at this time not sufficiently hyperstimulated to be readily attacked by *Pythium*.

We infer from this experiment that root growth of H 109 may be stimulated to the point that root rot becomes serious. This requires an excessive amount of plant food. The concentration required to induce susceptibility is so high that it is not likely to occur in the field or to be maintained long if reached accidentally in

localized areas. As soon as the concentration of nutrients becomes reduced as by use of the plant for growth, and leaching, normal root growth is resumed.

Effect of Molasses, Mudpress and Bagasse on Root Rot

In "Notes on *Pythium* Root Rot, V"* the effect of molashcake on root rot of Lahaina was discussed. Since this material was so effective in causing root rot of Lahaina in "healthy" soil, experiments were conducted separately on the main ingredients of molashcake to determine which ingredients were the most active. These experiments, Nos. 113, 114, 115, are discussed below. The results are given, in elaboration of the idea that it is the stimulative nature of the amendments that leads to root growth which is susceptible to the attack of *Pythium aphanidermatum*.

Experiment 113—Effect of Molasses on Root Rot

An experiment to test the effect of amendments of molasses, and molasses with sodium nitrate on root rot of Lahaina and H 109 in pathology plot soil, was conducted in 12-inch pots. There were control pots with no molasses, pots with one, two and three pounds of molasses respectively, and a series with the named amounts of molasses plus three grams of sodium nitrate per pot. One-half of the pots were planted with Lahaina and one-half with H 109.

The pots were filled with well mixed pathology plot soil. The molasses and molasses-plus-nitrate pots received the application of the amendments January 4, 1929. All pots were kept moist until March 28, 1929, to facilitate decomposition of the molasses. Planting was done on the latter date, with healthy cuttings from Kailua. Growth was fairly uniform throughout the series with somewhat better foliage color in plants grown in the amended soils. Stooling was also more vigorous in the amended soils. Correlated with this, there appeared to have been a stimulated root growth in the amended soil with serious root rot in the Lahaina, but scarcely a trace in the H 109. The roots of all plants were washed free of soil at the conclusion of the experiment June 25, 1929.

Table II shows the number of pots, treatment of soil three months before planting, cane variety and presence or absence of root rot. Fig. 1 shows the root systems of representative Lahaina plants. The experiment confirms an earlier one in that molasses amendment again induced serious root rot in a soil normally "healthy" for Lahaina cane. Root rot also appeared to be further aggravated by the addition of sodium nitrate to the molasses amendments.

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* Op. cit.

Fig. 1. Effect of molasses and nitrate of soda amendment on Lahaina roots. No. 1, Control, Lahaina; No. 4, Control, H 109; No. 6, Lahaina, one pound molasses amendment; Nos. 9 10, two pounds; No. 13, three pounds; No. 17, three pounds molasses plus 3 grams sodium nitrate.

TABLE II

Pot No.	Variety	Treatment	Root Rot
1	Lahaina	Control	None
2	Lahaina	"	"
3	H 109	"	"
4	H 109	"	"
5	Lahaina	1 lb. Molasses	Serious
6	Lahaina	"	"
7	H 109	"	Trace
8	H 109	"	None
9	Lahaina	2 lbs. Molasses	Serious
10	Lahaina	"	"
11	H 109	"	None
12	H 109	"	"
13	Lahaina	3 lbs. Molasses	Serious
14	Lahaina	"	"
15	H 109	"	None
16	H 109	"	"
17	Lahaina	1 lb. Molasses, 3 gm. $NaNO_3$	Extreme
18	Lahaina	" "	"
19	H 109	" "	None
20	H 109	" "	"
21	Lahaina	2 lbs. Molasses, 3 gm. $NaNO_3$	(No Germination)
22	Lahaina	" "	Extreme
23	H 109	" "	None
24	H 109	" "	"
25	Lahaina	3 lbs. Molasses, 3 gm. $NaNO_3$	Extreme
26	Lahaina	" "	"
27	H 109	" "	None
28	H 109	" "	"

Experiment 114—Effect of Bagasse on Root Rot

An experiment with pathology plot soil with bagasse, and with bagasse and nitrate of soda amendments was conducted in 12-inch pots. This experiment was designed to reveal the effect of relatively inert organic matter on Lahaina roots. Well mixed pathology plot soil was used. Control soil and amended soil units were prepared as shown in Table III, January 9, 1929. These were kept moist until March 30 or about three months, to allow decomposition, at which time all were planted with healthy Lahaina cuttings from Kailua.

Growth as estimated by size of tops and color of foliage was somewhat depressed in all the amended soils. Stooling was rather poor also in comparison with the controls. The roots were washed free of soil June 25, 1929.

There was no stimulation of root growth such as was found conspicuous in amendments of stable manure, molasses or cane compost, and no root rot. All roots remained of small size, thread-like or fibrous. The controls in pathology plot soil showed a few large roots with some insignificant *Pythium* root rot.

It was noted that the bagasse had not decomposed to any great extent, even in the presence of the nitrate of soda, during the five months of the experiment. The pots were in the open and exposed to rains.

Fig. 2. Effect of bagasse and nitrate of soda amendments on Lahaina roots. No. 11 Control. No. 1, one pound bagasse; No. 5 same as No. 1 plus 3 grams nitrate; No. 7 same as No. 1 plus 5 grams nitrate; No. 10 same as No. 1 plus 10 grams nitrate.

There was no apparent stimulating effect by the amendments, and there was no root rot induced by the bagasse as used. The results were interesting, conversely, since we are assuming as a working hypothesis that it is the hyperstimulated root system which is subject to *Pythium* attack. It also appeared that the bagasse controlled any tendency of the roots to be stimulated by the nitrate. Table III shows the details of the experiment and Fig. 2 shows the root systems of representative units. The better plants and roots were noticed in the controls. The bagasse-plus-nitrogen series was next in order. The plants and roots in soil amended with bagasse alone were noticeably the poorest of all.

TABLE III

Pot No.	Treatment	Root Rot
1	Bagasse 1 lb.	None
2	"	"
3	"	"
4	"	"
5	Bagasse 1 lb., 3 gm. $NaNO_3$	"
6	" "	"
7	Bagasse 1 lb., 5 gm. $NaNO_3$	"
8	" "	"
9	Bagasse 1 lb., 10 gm. $NaNO_3$	"
10	" "	"
11	Control	"
12	"	Trace
13	"	None
14	"	Trace

EXPERIMENT 115—EFFECT OF PRESS CAKE ON ROOT ROT

At the same time that the above experiments with molasses and bagasse were started, a simlair experiment was prepared with pathology plot soil and press cake amendments, with and without sodium nitrate. After an incubation period of about three months, the pots were planted with Lahaina cuttings from Kailua, on March 28, 1929.

Table IV shows number of pots, treatment and effect on root *health*. With 1 pound of press cake alone growth of roots as well as tops was moderately stimulated. There was only moderate root rot. With the same amount of press cake plus 3 grams of sodium nitrate, root growth was noticeably more stimulated as indicated by the larger size of roots. There was a conspicuous localization of root rot in the larger roots. With 5 grams of sodium nitrate the root systems were somewhat better, possibly with less root rot at the time observed. With 10 grams of sodium nitrate the roots were very badly reduced by root rot. They had been attacked nearly as fast as they developed and rotted off before they reached a length of six inches. The top was withering, dry and pale and there was a burning and firing of the lower leaves. Throughout the experiment there was a conspicuous firing of the lower leaves with some burning of the edges and tips of young leaves, most marked in pots Nos. 7, 8, 9 and 10.

Fig. 3. Effect of press cake and nitrate of soda amendments on Lahaina roots. Nos. 1 and 4, one pound of press cake. No. 5, same plus 3 grams sodium nitrate; Nos. 7 and 8 same plus 5 grams sodium nitrate. No. 9 same plus 10 grams sodium nitrate; No. 14 control.

Top growth, stooling and root growth were all stimulated by the additions of press cake and press cake plus nitrate of soda. This was accompanied by a tendency to root rot. Fig. 3 shows the root systems of representative units.

TABLE IV

Pot No.	Treatment	Root Rot	Leaf Burn
1	1 lb. Press Cake	Trace	None
2	"	Moderate	"
3	" (No germination)	.....	.....
4	"	Moderate	None
5	1 lb. Press Cake, 3 gm. $NaNO_3$	"	"
6	" "	Conspicuous	"
7	1 lb. Press Cake, 5 gm. $NaNO_3$	Trace	"
8	" "	Moderate	Present
9	1 lb. Press Cake, 10 gm. $NaNO_3$	Serious	"
10	" "	"	"
11	Control	None	None
12	"	"	"
13	"	"	"
14	"	"	"

Effect of Compost in Sterilized Soil Mixtures

It has been reported* that cane compost in amounts of 20 to 40 per cent by volume induced root rot of Lahaina in "healthy" Makiki soil. To note if compost *per se* exerted any harmful effect, or caused root collapse, mixtures of soil and compost were steam sterilized. Root study boxes were also sterilized and the soil placed therein. The various units and controls as shown in Table V were planted March 30 with Lahaina cuttings from Kailua, which had been cleaned and soaked ten minutes in a 1-1000 solution of mercury bichloride. The cuttings were rinsed thoroughly before planting. Plants were watered throughout the experiment with tap water. As shown in Table V, a parallel series was conducted with comparable mixtures, unsterilized, the cuttings having been similarly disinfected.

TABLE V

Box No.	Soil		Root Rot
1	Makiki soil	Sterilized	None
2	" "	"	"
3	Makiki soil 60 per cent + compost 40 per cent	"	"
4	" " " "	"	"
5	Makiki soil	Unsterilized	"
6	" "	"	"
7	Makiki soil 60 per cent + compost 40 per cent	"	Moderate
8	" " " "	"	"

The roots were washed June 29, 1929. It was significant that although the roots were stimulated in the sterilized soil to better development and formation of larger sized roots than is usual for natural Makiki soil, no root collapse was

* Notes on *Pythium* Root Rot, IV, *Hawaiian Planters' Record*, Vol. XXXII, No. 4, p. 468.

present in the absence of specific organisms. With compost added there was a considerably greater stimulation of root development with large roots predominating, yet no root rot occurred in this sterilized amended soil.

In the unsterilized soil without amendments no root rot occurred. The roots were mostly of the small, fibrous type associated with soils only moderately supplied with nitrogen. With compost, however, in the unsterilized soil the roots were stimulated to better development. Considerable root rot was present in these root boxes (Nos. 7 and 8).

Paralleling the last mentioned experiment with compost, a similar experiment was conducted simultaneously and in the same manner with stable manure. Table VI shows the observations made when the roots were washed after a growing period of three months.

TABLE VI

Box No.	Soil		Root Rot
1	Makiki soil	Sterilized	None
2	" "	"	"
3	Makiki soil 80 per cent, manure 20 per cent	"	"
4	" " "	"	"
5	Makiki soil	Unsterilized	"
6	" "	"	"
7	Makiki soil 80 per cent, manure 20 per cent	"	Serious
8	" " "	"	"

Root rot was found only in the unsterilized soil amended with 20 per cent manure. These units had a very poor root system. In the soil alone, the roots were noticeably darker colored in the unsterilized than in the sterilized soil, but apparently equally healthy.

Olaa Soil Studies

Soil in Field J-2 at the Olaa Sugar Co., Ltd., has proved decidedly unfavorable for Lahaina cane. Soil at Makiki still grows fair Lahaina. Raymond Conant, agriculturist, Olaa Sugar Co., Ltd., collected Olaa soil for the following experiment, which was conducted at Makiki, to note the effect on root health of Lahaina grown in various mixtures of the two soils, i. e., Olaa and Makiki.

Duplicate root study boxes were prepared of Olaa soil and of nine series of dilution, ranging from one-tenth Olaa soil mixed with nine-tenths Makiki soil, to nine-tenths Olaa soil and one-tenth Makiki soil. Table VII shows the arrangement and results observed. The units were planted March 30, 1929, with healthy Lahaina cuttings from Kailua, cleaned, soaked in 1-1000 bichloride of mercury for ten minutes and thoroughly rinsed.

TABLE VII

Box No.	Soil	Germination	Improved Root Health Over Check	Root Rot
1	Control Olaa soil	—		.....
2	" " "	+		Bad
3	" " "	+		"
4	" " "	—		.....
5A	Olaa soil 9/10, Makiki soil 1/10	+	None	Bad
5B	" " " " " "	+	"	"
6A	Olaa soil 8/10, Makiki soil 2/10	+	"	"
6B	" " " " " "	+	"	"
7A	Olaa soil 7/10, Makiki soil 3/10	+	?	"
7B	" " " " " "	+	?	"
8A	Olaa soil 6/10, Makiki soil 4/10	+	Slight	"
8B	" " " " " "	+	"	"
9A	Olaa soil 5/10, Makiki soil 5/10	+	Marked	Moderate
9B	" " " " " "	+	"	"
10A	Olaa soil 4/10, Makiki soil 6/10	+	"	"
10B	" " " " " "	+	"	"
11A	Olaa soil 3/10, Makiki soil 7/10	+	"	"
11B	" " " " " "	+	"	"
12A	Olaa soil 2/10, Makiki soil 8/10	+	Very marked	Trace
12B	" " " " " "	+	" "	"
13A	Olaa soil 1/10, Makiki soil 9/10	+	" "	"
13B	" " " " " "	+	" "	None
14A	Makiki soil	+	Normal	"
14B	" "	+	"	"

The root systems of this series of plants were washed after a growing period of three months. In the "sick" Olaa soil and in the mixtures wherein this soil predominated over the "healthy" Makiki soil root rot was prevalent. However, there was a rapid decrease of root rot in the series up to the half-and-half mixture, with a more gradual decline as the proportion of healthy soil was further increased. The contrast in root health was particularly marked when the root systems grown in soil mixtures containing more than one-half Olaa soil were compared with those grown in mixtures containing less than one-half Olaa soil. Figs. 4 and 5 illustrate this comparison, the root systems of typical representatives of the series of plants being shown. The relative length and density of roots are shown, though the degree of health or rotting is not discernible in such photographs. Root rot was inconsequential where Olaa soil was present in amounts of 20 to 30 per cent by volume.

Fig. 4. Effect on Lahaina roots of dilution of Olaa "sick" soil with Makiki "healthy" soil. No. 2, Olaa soil; No. 5, Olaa soil 9/10, Makiki 1/10 by volume; No. 6, Olaa soil 8/10, Makiki soil 2/10; No. 7, Olaa soil 7/10, Makiki soil 3/10; No. 8, Olaa soil 6/10, Makiki soil 4/10.

Fig. 5. (Fig. 4 cont.). No. 9, Olaa soil 5/10, Makiki soil 5/10; No. 10, Olaa soil 4/10, Makiki soil 6/10; No. 11, Olaa soil 3/10, Makiki soil 7/10; No. 12, Olaa soil 2/10, Makiki soil 8/10; No. 13, Olaa soil 1/10, Makiki soil 9/10.

Discussion

In an earlier experiment* it was found that when molashcake was allowed to decompose in healthy soil, the latter became a "sick" soil for Lahaina cane; root rot was greatly aggravated in Waipio sick soil by smaller amendments of molashcake. It was found in the present studies that molasses and press cake, the chief nutrients in molashcake, stimulated growth and were active in producing root rot conditions of a healthy soil, while bagasse was not. The latter depressed growth, counteracted any stimulating tendency of the sodium nitrate present, and no root rot occurred. Bagasse might have a useful role as a soil amendment in suitable combinations with molasses to retard disintegration, extend beneficial effects and check any harmful tendencies. That this material can be used as a dry carrier for molasses has been demonstrated by J. A. Verret† and F. E. Hance. Suitable formulae from the viewpoint of desirable biological effects in various soils might be quite different from a mechanical mixture most convenient for field application.

Experiments above cited showed that cane compost or stable manure amendments did not *per se* cause root collapse (Tables V and VI). These materials served as stimulative plant foods, the roots in such steam sterilized amended soil being large and healthy. No root rot occurred, nor any semblance of root collapse. In such amended soils not steamed, *Pythium* root rot was severe. Steam sterilization of a healthy soil has been observed to bring about conditions favorable for root rot, and this disease occurred as soon as *Pythium* was present.

In another experiment, above cited, a "sick" soil was diluted progressively with "healthy" soil, and the effect on the roots of Lahaina observed. As the proportion of "sick' soil decreased root rot became less severe. Improvement in root health was marked when the sick soil was about one-half of the mixture. Root rot all but disappeared in mixtures where the sick soil was but 20 per cent of the whole.

As already reported root rot has been induced in healthy soils by amendments of cane compost, stable manure, molashcake, mud press, molasses and sodium nitrate. These materials, whatever their other characteristics, act as stimulative plant foods. With bagasse amendments, as used, any stimulative tendency of the nitrate of soda present was overbalanced, growth was depressed and no root rot occurred. Traces of root rot did occur in some of the "healthy" soil controls. The Makiki soil is so nearly free of *Pythium* root rot of Lahaina as compared to field soils where this cane suffers severely that it is called "healthy" in these notes.

Accumulated experimental evidence thus shows that a "healthy" soil can be made "sick" for Lahaina cane by stimulative amendments, or by other means of increasing available nutrients, as by steam sterilization and subsequent invasion by *Pythium* species. The harmful accessory factor of *Pythium* in a "sick" field soil can be rendered impotent by dilution of the soil with healthy soil. In view of these

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* Notes on *Pythium* Root Rot, V, *Hawaiian Planters' Record*, Vol. XXXIII, No. 2, p. 164.

† Report by J. A. Verret, in Director's Monthly Report, September, 1927; also Proceedings, H. S. P. A., 1927, pp. 89-90.

premises it seems obvious that *Pythium* root rot varies in severity with the concentration of stimulative nutrients.

The theory was advanced* that susceptibility to *Pythium aphanidermatum* was acquired by the roots, and that it was a temporary condition of the root system varying with soil environment. The controlling factor in this acquired susceptibility now appears to be rate and type of growth as determined by stimulative nutrients. The alternate theory, that increased root rot might be due to the stimulative effect of these environments on the fungus, remains to be considered. Experiments may be conducted to learn whether the parasitic tendencies of *Pythium* can be increased by culturing the organism on various stimulative media. Since parasitic ability of the *Pythium* cultures has not been a difficulty encountered in experiments over several years, the impression has been gained that root modification was a more logical inference, than variability in the habit of the fungus. It does not appear logical that *Pythium per se* requires 5 per cent of stable manure in a soil to enable it to attack Lahaina, and around 50 per cent of the same amendment to enable it to attack H 109 seriously. The literature supports the view that a too stimulative environment for plants leads to the development of tissues more susceptible to fungus attack.

From a practical viewpoint, if *Pythium* becomes a harmful factor in cane culture only in over stimulative soils, it does not appear very important to know whether the cane, the fungus or both are modified in behavior by the environment.

Summary

1. Serious root rot of H 109 caused by *Pythium aphanidermatum* was induced in a potted soil by amendments of stable manure, 25 per cent to 50 per cent by volume. It is inferred that the observed later resumption of healthy root growth was the result of a reduced concentration of the stimulative nutrients by assimilation and leaching.

2. Root rot of Lahaina was induced in a "healthy" soil by amendments with molasses and mud press respectively. Bagasse, another constituent of molashcake, depressed growth, and no root rot occurred. The previously reported adverse effect of molashcake on root rot was apparently due to the stimulative ingredients, molasses and mud press, and not to the bagasse.

3. No root collapse of Lahaina was found in soil amended with manure or compost and steam sterilized. In such amended soils, not sterilized, *Pythium* root rot was active. Heavy amendment with these materials did not *per se* cause root collapse.

4. When a "sick" soil was diluted progressively with a healthy soil, *Pythium* root rot became less severe. With a half-and-half mixture, a marked improvement of root health was observed. In mixtures containing less than 20 to 30 per cent sick soil, *Pythium* root rot became inconsequential.

* Notes on *Pythium* Root Rot, III, *Hawaiian Planters' Record*, Vol. XXXII, No. 3, pp. 279-288.

5. It is inferred from these experiments that the accessory controlling factor in *Pythium* root rot of Lahaina cane is the type of root growth as determined by stimulative nutrients. Temporarily acquired susceptibility appears to be a function of root nutrition when the nutrients available become too stimulative. In lesser amounts this harmful factor acts as a beneficial soil constituent.

A Comparative Study of the Development of Sugar Cane Roots from Root Primordia

By D. M. Weller

In undertaking a study of the length of life and the duration of the functioning periods of roots of the sugar cane plant, consideration was given to the root primordia, which occur as "root dots" at the base of the internodes of the stems and which, on planted cane cuttings,* develop into "seed-piece roots." In this study consideration was given to the development of these primordia into seed-piece roots and to the time of development of shoot roots in relation to the stage of development of the seed-piece roots for several varieties of cane.

The present experiment (performed in May and June of 1928) was planned to determine (1) the number of root primordia and, therefore, the possible number of seed-piece roots per node for different varieties of cane, (2) the percentage of root primordia "germinating" at stated intervals under field conditions, (3) whether or not any of these root primordia are held in reserve, (4) the time of development of shoot roots in relation to the stage of development of the seed-piece roots, (5) whether or not there exists any correlation between the germination of the root primordia and the development of the buds into shoots, and (6) what variation exists in regard to these points among the varieties H 109, Lahaina, Yellow Caledonia, D 1135, Uba, P. O. J. 213, and P. O. J. 36.

It was impossible to secure cuttings of all of these varieties from the same source and of the same age, but uniform "top seed" of each variety was used. Fifty three-eye cuttings of each of the above mentioned varieties were selected. The number of root primordia of each of the three nodes of each cutting was counted and recorded. The average number per node of the 150 nodes of the seven varieties named above are shown in Table I.

TABLE I

Showing the Average Number of Root Primordia per Node of 50 Three-Eye Cuttings of Several Varieties of Cane

D 1135	122.66
H 109	116.84
Yellow Caledonia	114.43
Lahaina	93.56
P. O. J. 213	45.00
Uba	38.46
P. O. J. 36	29.62

* In Hawaii commonly known as "seed pieces"; in India, as "setts"; in Java, as "bibits"; in the Philippines, as "points" or "semillas."

It is seen from these figures that there is in regard to this character a great variation among these varieties. No doubt also in any particular variety this character varies greatly with age and growing conditions. This was illustrated by taking at random three sticks of Uba cane from a field other than the one from which the 50 pieces of top seed of this variety were gotten. These sticks were cut off close to the ground and, beginning with the lowest node and proceeding acropetally, the number of root primordia were counted on all nodes of the three sticks. Three sticks each of the varieties D 1135, H 109, and Yellow Caledonia were treated in the same way. The average number of root primordia per node for the three sticks of these four varieties was as follows:

Yellow Caledonia	220.09
H 109	95.66
D 1135	83.80
Uba	39.16

A comparison of these data with those of Table I shows that great variation exists within the variety also and suggests that possible correlations exist between these numbers and age of cane, season, nutrition, pH of soil, etc. The discovery of such correlations would be profitable provided it can be shown that *for a given variety* either quickness of germination of the buds, or "stand" of cane is dependent upon the number of these root primordia. Of course between the varieties there is no such correlation as is evidenced by Figs. 1 to 4.

Plan of the Experiment

When the number of root primordia on the 50 three-eye cuttings of each of the seven varieties named above were recorded, the cuttings were planted at random in the field and irrigated at the rate of one acre-inch of water every 5 days.

The 50 cuttings of each variety were divided into five groups of 10 each. Those of each variety belonging to Group I, were removed from the ground 5 days after they were planted, the number of developing root primordia on them counted and recorded and the percentage this number was of the total number of root primordia calculated. (Fig. 1.)

The number of shoot roots was also recorded. All developing roots were then cut off close to their proximal ends and the seed pieces replanted. At the end of a second period of 5 days in the ground these seed pieces were again removed from the soil and the number of developing roots counted and cut off as before. This operation was repeated at intervals of 5 days for 50 days.

The seed pieces of each variety belonging to Group II were treated as were those of Group I except that they were taken up and replanted at intervals of 10 days for 50 days. (Fig. 2.)

Group III was treated in the same way at intervals of 15 days, Group IV at intervals of 25 days (Fig. 3), Group V at the end of one interval of 50 days (Fig. 4). The irrigations were so timed as to be given immediately after every planting.

The number of seed-piece roots counted in this way is recorded in Table II.

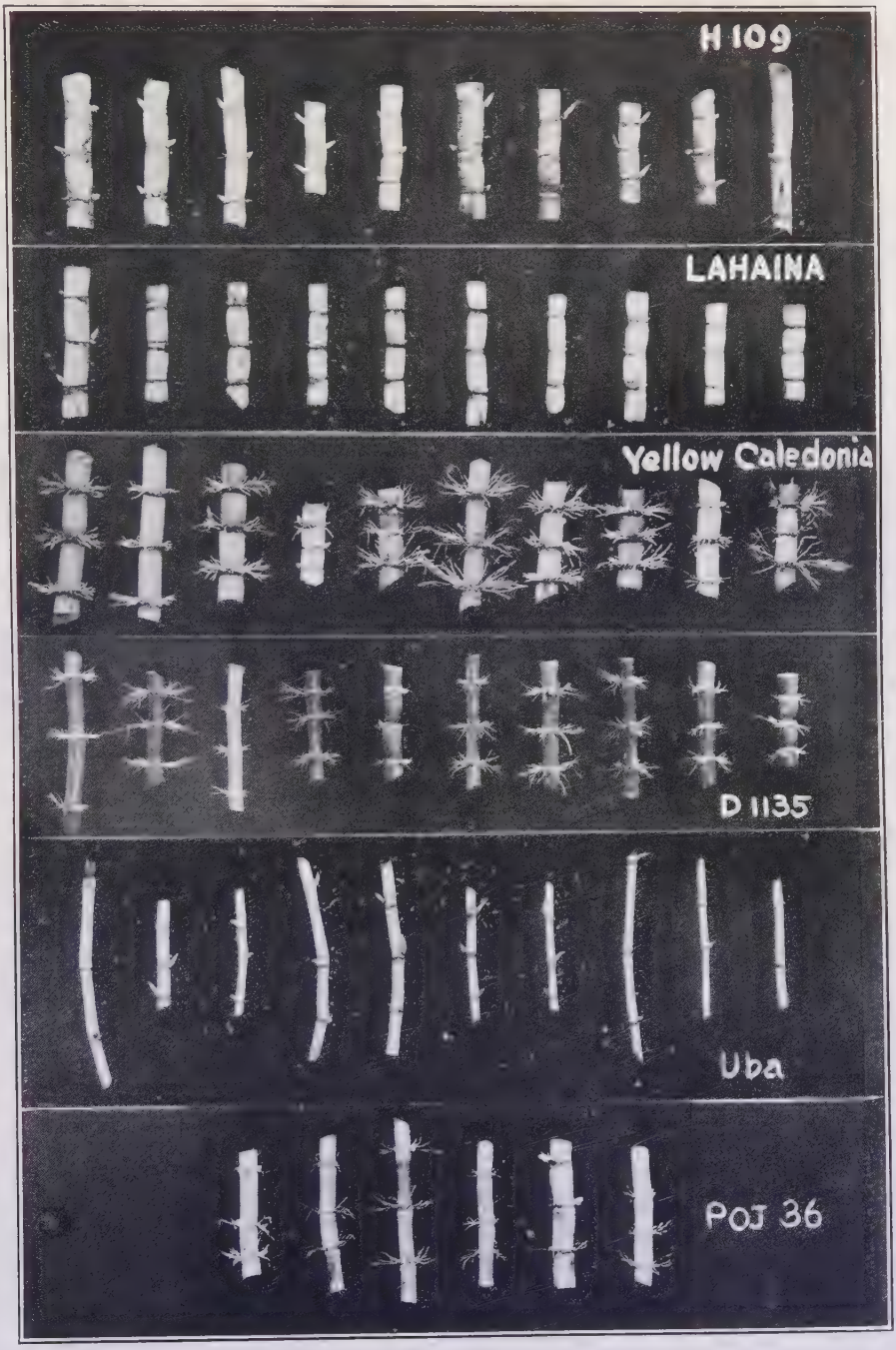

Fig. 1. Showing the relative development of seed-piece roots from the root primordia, or "root dots," the stage of development of the "eyes" into the shoots, and the general appearance of seed pieces of Group I after being planted in the ground for the first of ten 5-day periods, and receiving irrigation water at the rate of one acre-inch when planted.

Fig. 2. Showing the relative development of seed-piece roots and shoots from the seed pieces of Group II after being planted in the ground for the first 10-day period and being irrigated once when planted and once 5 days later at the rate of one inch per acre.

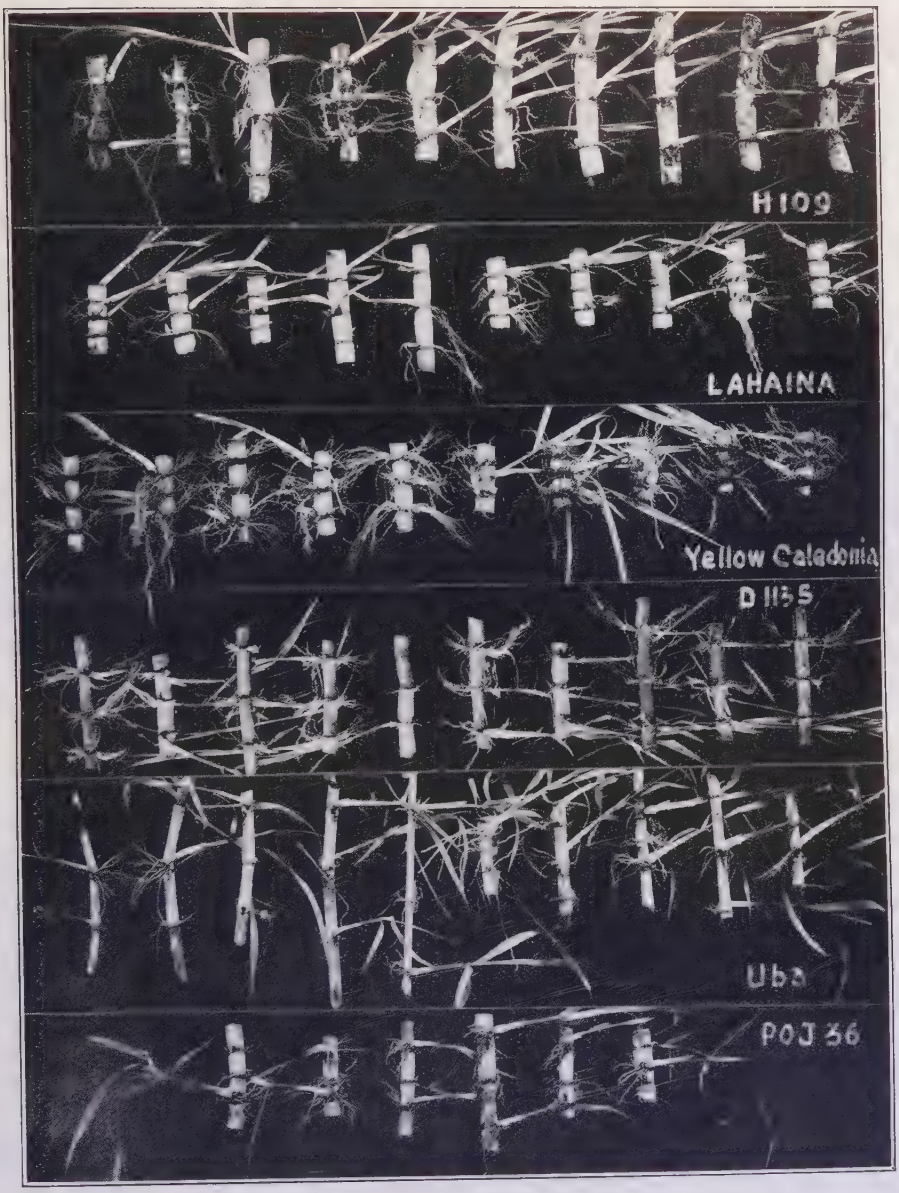

Fig 3. Showing the relative development of seed-piece roots and shoots from the seed pieces of Group IV after being planted in the ground for the first 25-day period and receiving five rounds of irrigation water at the rate of one acre-inch every 5 days.

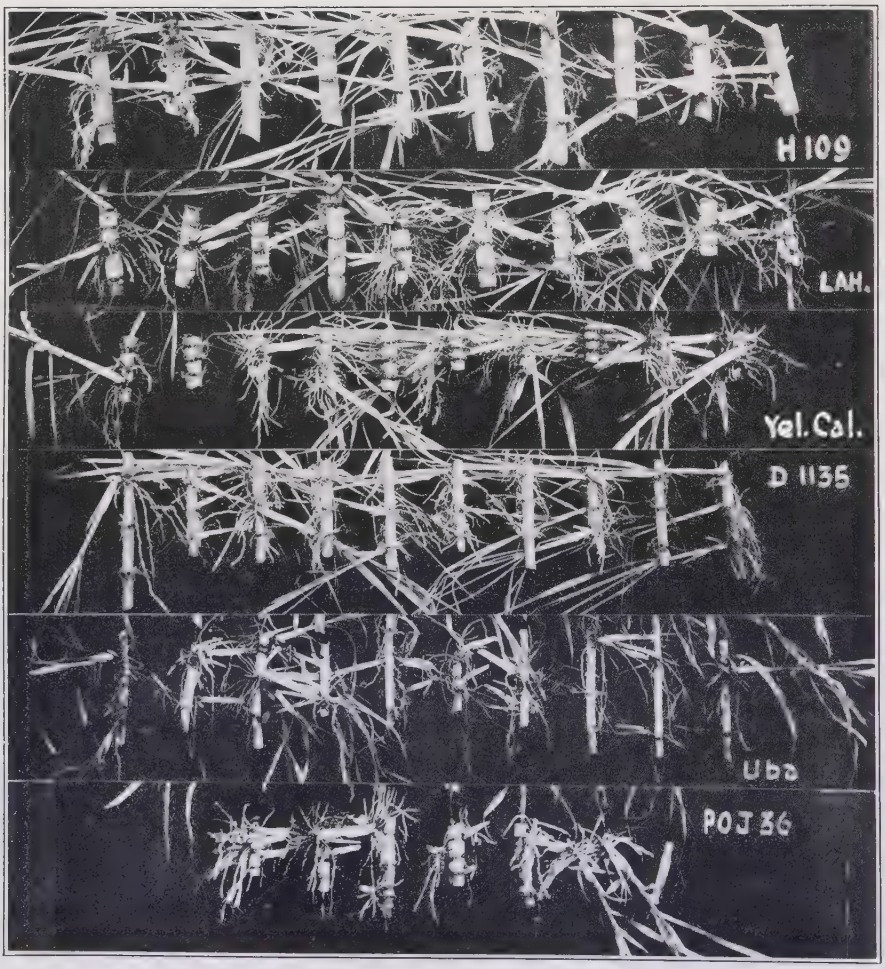

Fig. 4. Showing the relative development of seed-piece roots and shoots from the seed pieces of Group V after being in the ground "undisturbed" for a period of 50 days and receiving ten irrigations at the rate of one acre-inch every 5 days.

TABLE II

Showing the number of root primordia for each group of cuttings of the seven varieties of cane, and both the number and the per cent of these primordia developing into seed-piece roots after each interval of 5, 10, 15, 25, and 50 days

Group	No. of Seed Pieces	Variety	No. of Root Primordia	DAYS AFTER PLANTING — 5		10		15		20		25		30		35		40		45		50		TOTAL	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	
I	10	H 109	3829	139	3.6	753	19.6	445	11.6	160	4.1	143	3.7	11	0.2	11	0.2	0	0.0	0	0.0	1	0.2	1663	43.4
	10	Lahaina	3016	105	3.4	273	9.0	248	8.2	146	4.8	453	15.0	310	10.2	51	1.6	39	1.2	3	0.09	1	0.03	1629	54.0
	10	Yel. Cal.	4438	2871	64.6	474	10.6	244	5.4	100	2.2	103	2.3	82	1.8	32	0.7	73	1.6	19	0.4	2	0.04	4000	90.1
	10	D 1135	3692	1648	44.6	487	13.1	305	8.2	44	1.1	28	0.77	19	0.78	1	0.02	0	0.0	0	0.0	0	0.0	2542	68.8
	10	Uba	1059	63	5.9	64	6.0	99	9.3	15	1.4	70	6.6	12	1.1	0	0.0	1	0.09	0	0.0	0	0.0	324	30.6
	10	P. O. J. 213	1369	445	32.5	121	8.8	168	12.2	20	1.4	68	4.9	21	1.6	1	0.07	3	0.2	9	0.6	0	0.0	856	62.5
	10	P. O. J. 36	1441.6*	973.3	67.8	145.0	10.1	126.6	8.8	0	0.0	10	0.6	3.3	0.2	3.3	0.2	0	0.0	0	0.0	0	0.0	1264.1	87.7
II	10	H 109	3346			1146	34.2			764	22.8			87	2.6			27	0.8			17	0.5	2041	60.9
	10	Lahaina	2804			553	19.7			464	16.5			381	13.7			101	3.6			66	2.3	1570	55.9
	10	Yel. Cal.	3459			2711	78.3			478	13.8			93	2.7			8	0.2			3	0.1	3293	95.2
	10	D 1135	3734			1288	34.4			710	19.0			147	3.9			26	0.6			4	0.1	2175	58.2
	10	Uba	1235			173	14.0			157	12.7			85	6.8			17	1.3			1	0.08	433	35.0
	10	P. O. J. 213	1595			729	48.4			351	23.3			69	4.5			4	0.2			1	0.06	1093	72.5
	10	P. O. J. 36	1600.0*			920	57.5			299	18.7			66.0	4.1			9	0.6			8	0.5	1294.9	80.9
III	10	H 109	3668					1329	36.2					284	7.8					10	0.2			1628	44.4
	10	Lahaina	2825					709	25.0					672	23.7					64	2.2			1445	51.1
	10	Yel. Cal.	3274					2213	67.6					544	16.6					9	0.2			2768	84.5
	10	D 1135	3534					1688	47.7					332	9.1					9	0.2			2029	57.1
	10	Uba	1312					261	19.8					193	14.7					21	1.6			475	36.2
	10	P. O. J. 213	1287					556	43.2					241	18.7					8	0.6			805	62.5
	10	P. O. J. 36	1523.3*					923.3	60.6					226.6	14.8					0	0.0			1149.9	75.4
IV	10	H 109	3296									1109	33.6									343	10.4	1452	44.0
	10	Lahaina	2653									629	23.7									173	6.5	802	30.2
	10	Yel. Cal.	3021									2380	78.7									196	6.4	2576	85.1
	10	D 1135	3955									1642	41.5									113	2.8	1755	44.3
	10	Uba	1138									410	36.0									77	6.7	487	42.7
	10	P. O. J. 213	1312									875	66.6									68	5.1	943	71.8
	10	P. O. J. 36	1520.0*									853.3	56.1									110	12.0	963	63.1
V	10	H 109	3387																			1213	35.8	1213	35.8
	10	Lahaina	2737																			746	27.2	746	27.2
	10	Yel. Cal.	2973																			1879	63.2	1879	63.2
	10	D 1135	3484																			1847	53.0	1847	53.0
	10	Uba	1026																			302	29.3	302	29.3
	10	P. O. J. 213	12078																			842	65.8	842	65.8
	10	P. O. J. 36	1326.6*																			941.6	70.9	941.6	70.9

* Because only six seed pieces of P. O. J. 36 were used in each group the counts for this variety were multiplied by 10/6 to make the data comparable with that for the other varieties.

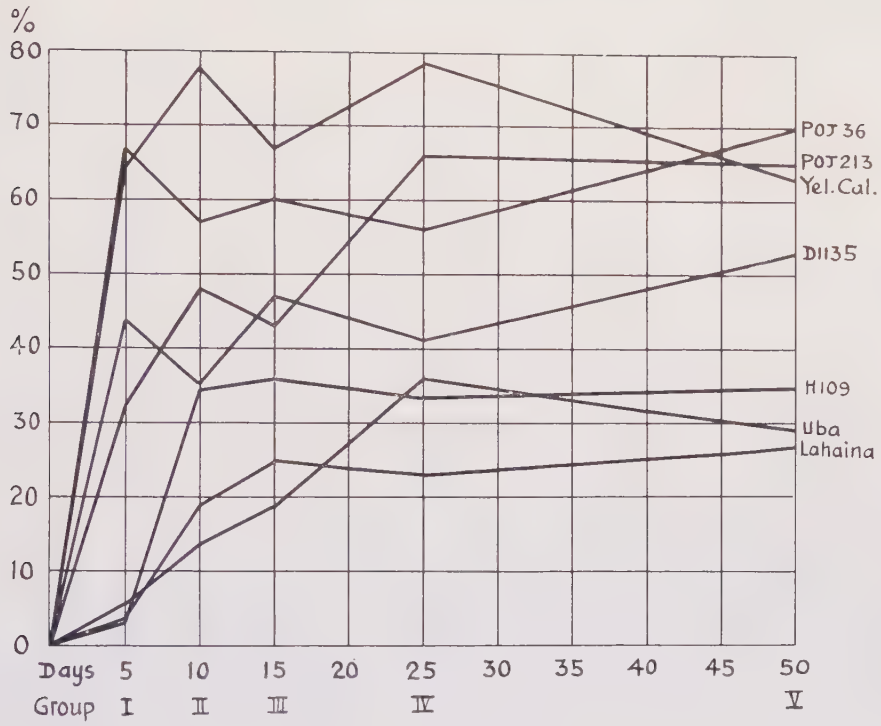

Fig. 5. Showing the percentage of root primordia developing into seed-piece roots on the five groups of seed pieces after being planted in the ground for the first period of 5 days (Group I), 10 days (Group II), 15 days (Group III), 25 days (Group IV), and 50 days (Group V).

The number and percentage of root primordia developing into seed-piece roots varied with the variety as is shown in Table II. From the data of Table II can be seen the number and per cent of root primordia developing into seed-piece roots at the end of the several periods. At the end of 5 days, for example, on the H 109 seed pieces of Group I, 139 root primordia, or 3.6 per cent of the total had developed into seed-piece roots, while on the Yellow Caledonia 2871, or 64.6 per cent, had developed into seed-piece roots. After being in the ground undisturbed for 50 days there had developed, on the Lahaina seed pieces of Group V, 746 seed-piece roots, or 27.2 per cent, while on those of the D 1135 of the same group 1847, or 53.0 per cent, had developed. Other varieties for these two periods as well as for other periods can be compared.

From Table II it can also be seen that, in general, after a period of 50 days the percentage of root primordia developing into roots was very little higher, if any, than the percentage developing in from 10 to 25 days. This is shown graphically in Fig. 5.

Root Primordia Held in Reserve

A comparison of the number of root primordia developing into seed-piece roots from the seed pieces undisturbed for 50 days with the number developing from those taken out and replanted at stated intervals is shown in Table III.

TABLE III

Showing the total per cents of the root primordia developing into seed-piece roots from the seed pieces undisturbed for 50 days, and for those disturbed at intervals of 5, 10, 15, and 25 days for 50 days. The figures opposite these per cents (in parentheses) followed by plus or minus signs indicate how much these total per cents were above or below the "average for the disturbed" seed pieces.

VARIETY	UNDISTURBED 50-Day Interval %	DISTURBED 5-Day Intervals %	DISTURBED 10-Day Intervals %	DISTURBED 15-Day Intervals %	DISTURBED 25-Day Intervals %	Average for Disturbed %
H 109	35.8 (12.3—)	43.4 (4.7—)	60.9 (12.8+)	44.3 (3.8—)	44.0 (4.1—)	48.1
Lahaina	27.2 (20.6—)	54.0 (6.2+)	55.9 (8.1+)	51.1 (3.3+)	30.2 (17.6—)	47.8
Yellow Caledonia	63.2 (25.5—)	90.1 (1.4+)	95.3 (6.6+)	84.5 (4.2—)	85.2 (3.5—)	88.7
D 1135	53.0 (4.1—)	68.8 (11.7+)	58.2 (1.1+)	57.1 (0.0)	44.3 (12.8—)	57.1
Uba	29.3 (6.8—)	30.5 (5.6—)	35.0 (1.1—)	36.2 (0.1+)	42.7 (6.6+)	36.1
P. O. J. 213	65.8 (1.8—)	62.6 (5.0—)	73.6 (6.0+)	62.5 (5.1—)	71.8 (4.2+)	67.6
P. O. J. 36	70.9 (7.0—)	87.5 (9.6+)	80.9 (3.0+)	75.4 (2.5—)	68.1 (9.8—)	77.9

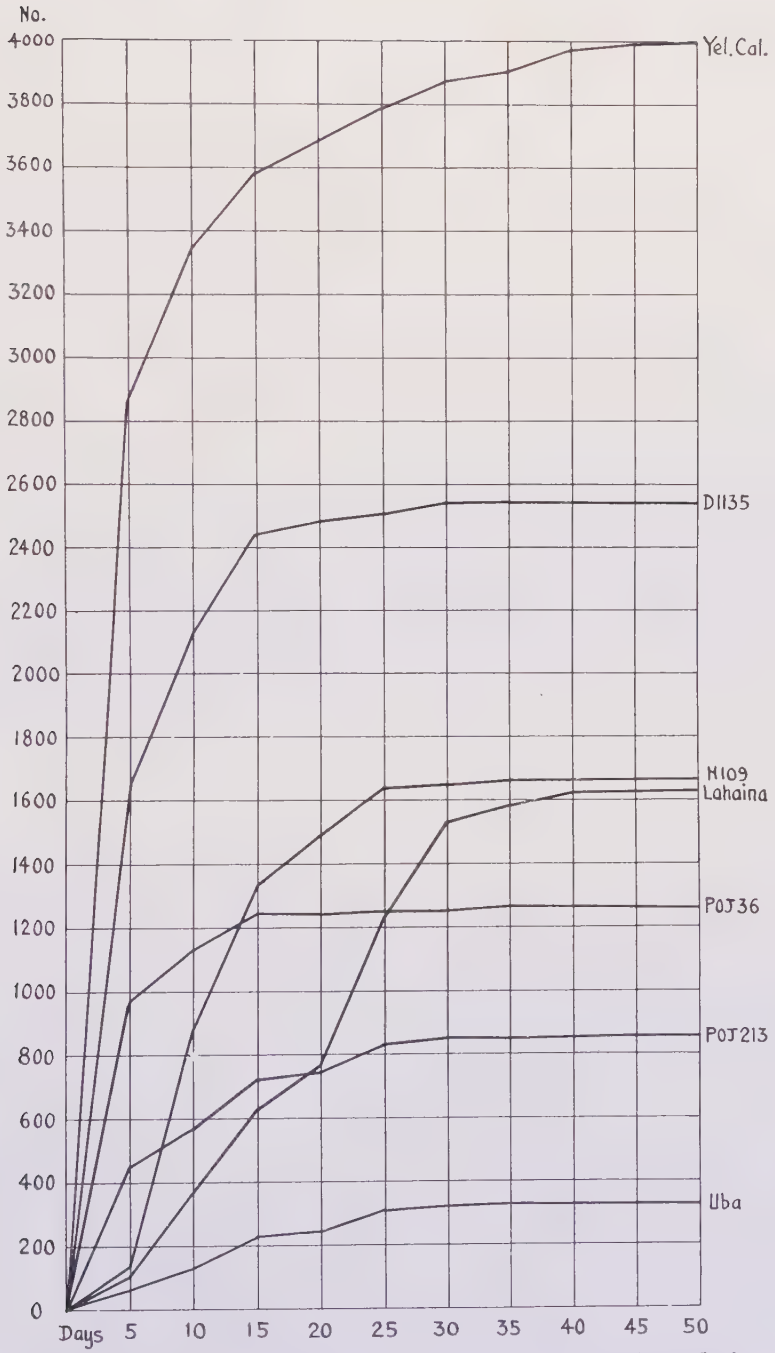

Fig. 6. Showing the total number of root primordia of the seed pieces of Group I which had developed into roots at the end of each of the ten 5-day periods.

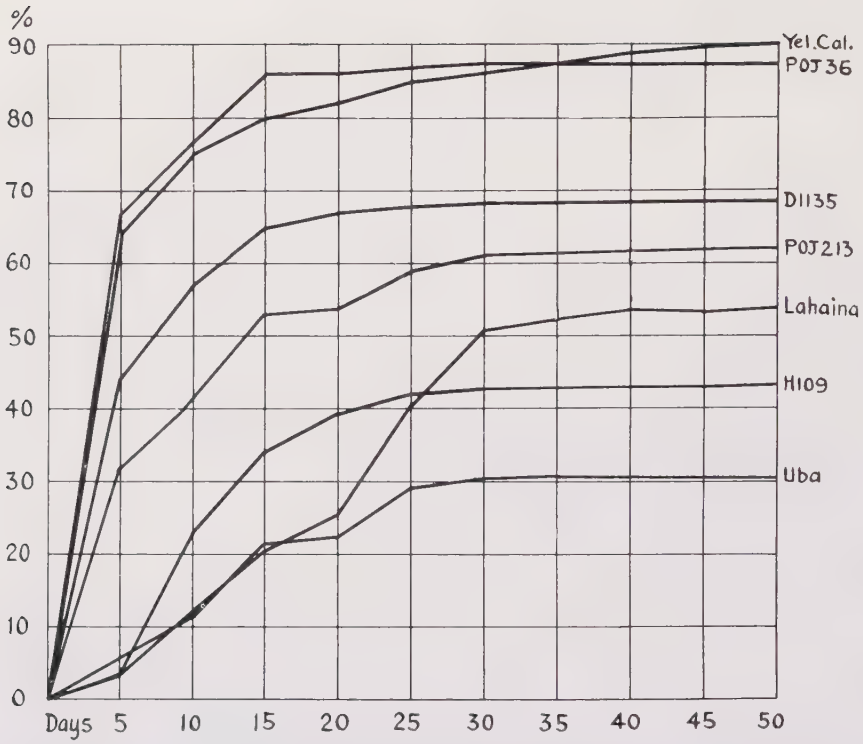

Fig. 7. Showing the total percentage of root primordia of the seed pieces of Group I which had developed into roots at the end of each of the ten 5-day periods.

It is interesting to note that in every case the total per cent of root primordia developing into seed-piece roots on the seed pieces left undisturbed for 50 days was less than the *average* of the total per cents of those removed from the ground and replanted at intervals of 5, 10, 15 and 25 days for 50 days, this difference being greatest for Yellow Caledonia, namely 25.5 per cent. This would indicate that, when the developed roots were cut off, *other primordia developed which under normal conditions would not have done so.* In other words *a certain number of root primordia is held in reserve and develop only in case of need* (Figs. 6 and 7).

For this reason the curves of Figs. 6 and 7 have a persistent tendency to rise continuously up to the fiftieth day, which is in contrast to the tendency of the curves of Fig. 5 to level off after the first 5 days. This may find practical application in the practice of off-barring and sub-soiling and will be discussed more fully in connection with the development of roots from the shoots.

From the graphs of Figs. 8 and 9 can be seen how the total number and percentage of root primordia developing into roots is greater for seed pieces "disturbed" over a period of 50 days at intervals of 5 or 10 days than for those "disturbed" at intervals of 15, 25 or 50 days. In the case of Uba, however, there is seen to be a slight deviation from this tendency. In Fig. 10, this fact is shown still more clearly for the variety Yellow Caledonia.

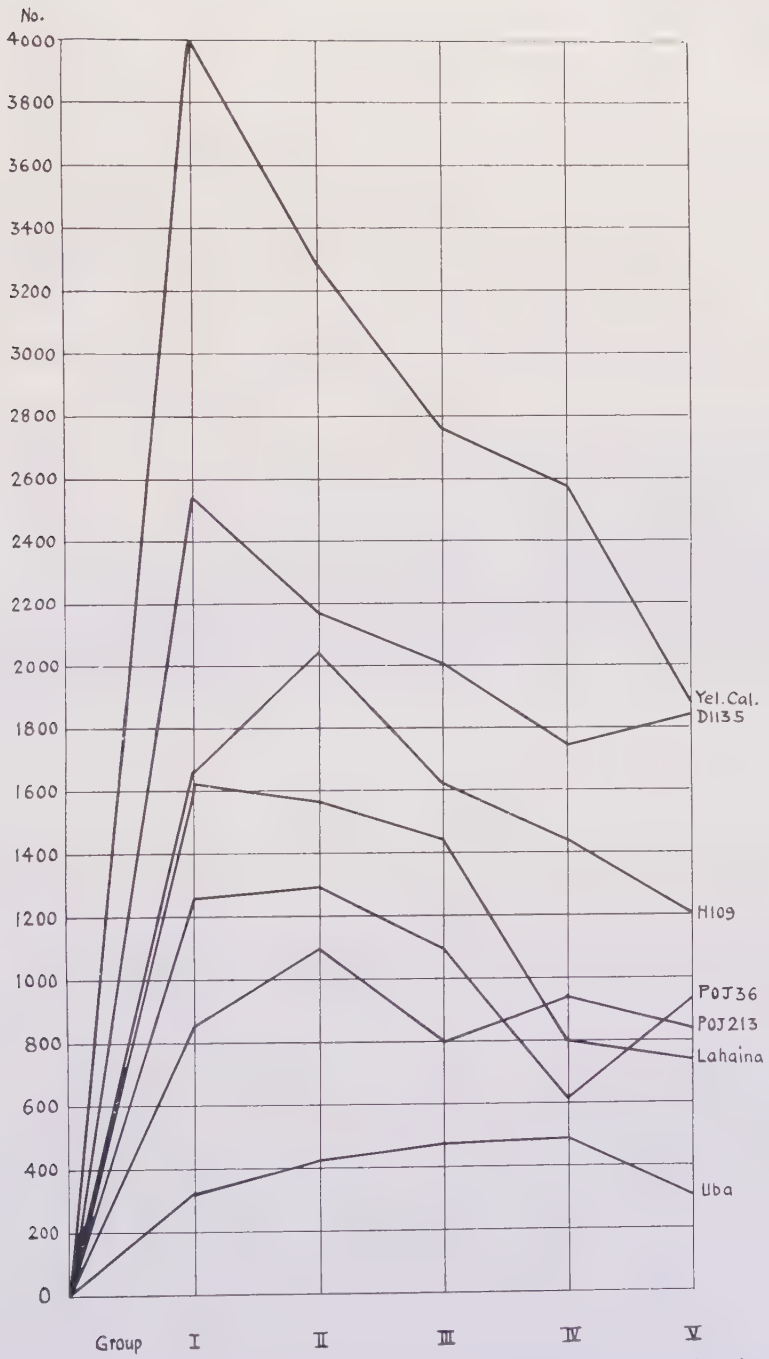

Fig. 8. Showing the total number of root primordia developing into roots at the end of ten 5-day periods (Group I), five 10-day periods (Group II), three 15-day periods (Group III), two 25-day periods (Group IV), and one 50-day period (Group V).

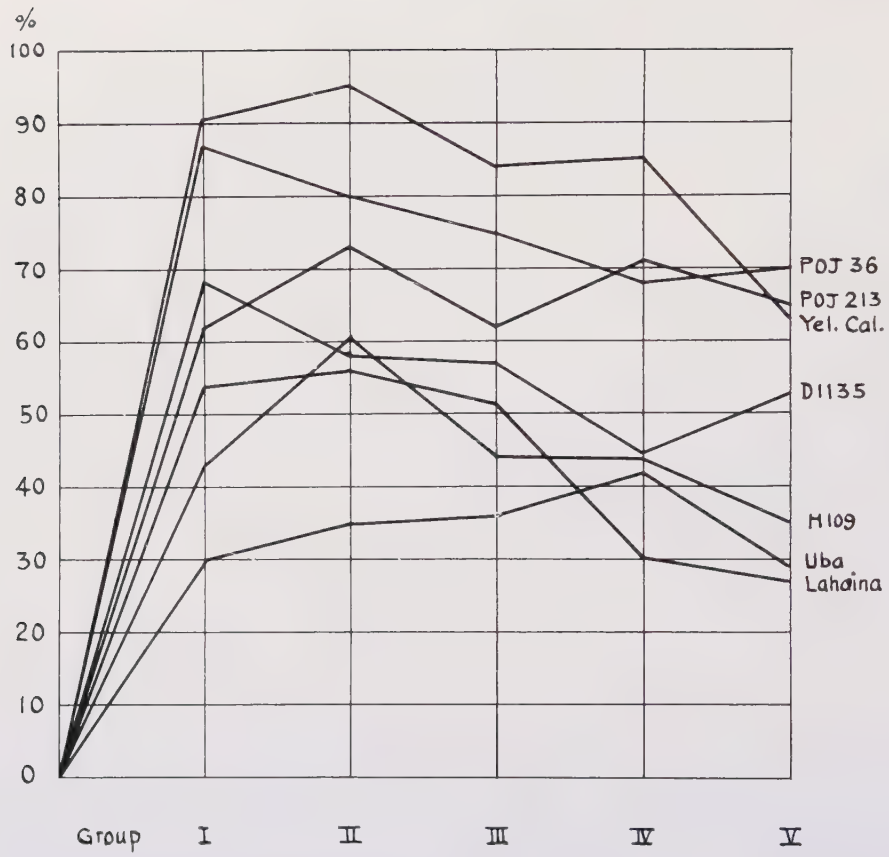

Fig. 9. Showing the total percentage of root primordia developing into roots at the end of ten 5-day periods (Group I), five 10-day periods (Group II), three 15-day periods (Group III), two 25-day periods (Group IV), and one 50-day period (Group V).

The Development of Shoot Roots

It has been shown that the seed-piece roots of the cane plant function only until the shoot develops from the bud and puts out roots of its own.* A bud from which such a shoot develops is essentially a miniature shoot with greatly shortened internodes and nodes bearing scales instead of leaves. In the axils of these bud scales are root primordia just as there are root primordia on the root band (Keimring) of the mature shoot. It is not surprising, therefore, to find shoot roots developing and pushing out from between the bud scales even when the internodes of the bud have only begun to lengthen.

When the seed pieces of Group I were dug up after the first 5-day period in the ground, from between the scales of some of the buds on seed pieces of Yellow Caledonia shoot roots had already developed. These roots are scarcely distinguishable from the seed-piece roots in Fig. 1.

* Lee, H. Atherton, and Weller, D. M. 1927. The Length of Life of Seed-Piece Roots and the Progress of Sugar Cane Roots in the Soil at Different Ages of Growth. The Hawaiian Planters' Record, Vol. XXXI, pp. 25-35.

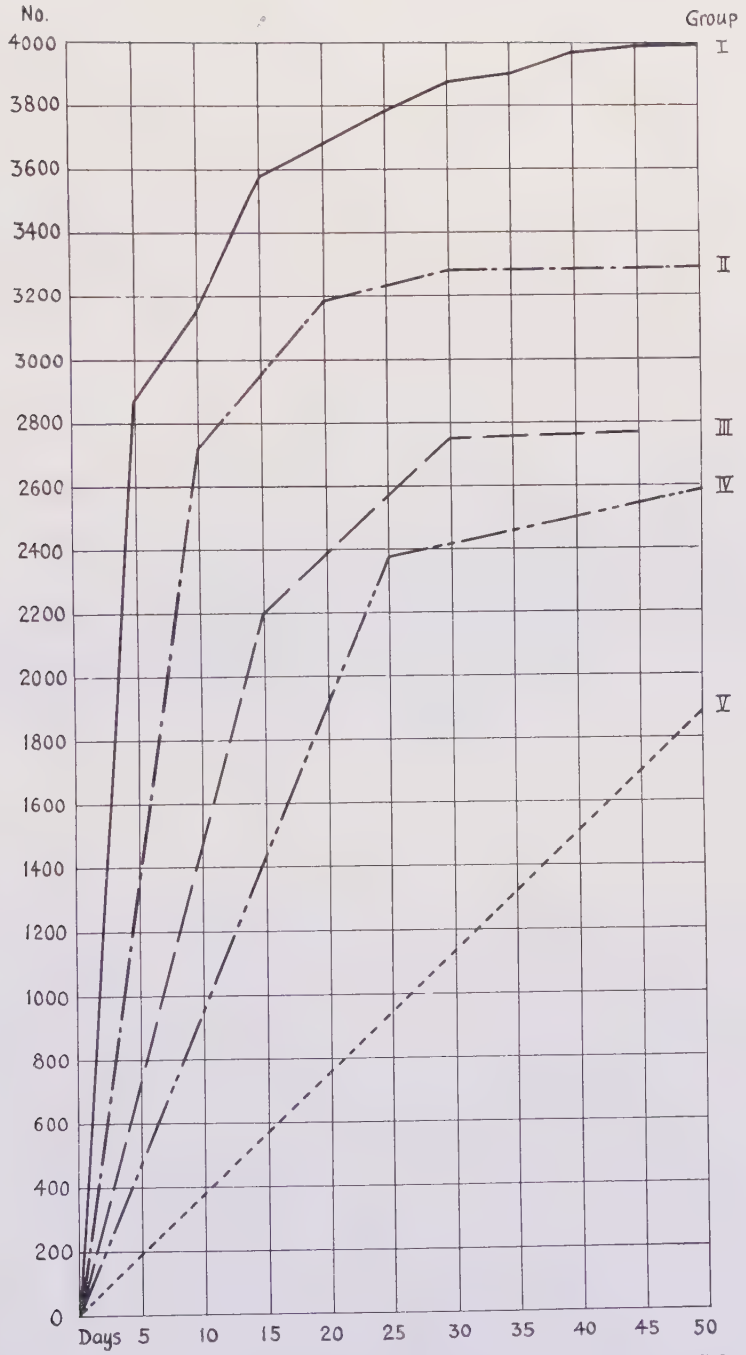

Fig. 10. Showing the number of root primordia of Yellow Caledonia developing into roots on seed pieces dug up, the developing roots cut off, and the seed pieces replanted at intervals of 5 days (Group I), 10 days (Group II), 15 days (Group III), 25 days (Group IV), and 50 days (Group V), for 50 days.

In Fig. 11 is shown a node of a seed piece of the variety P. O. J. 36 at the end of the second 5-day period in the ground. In the illustration it can be seen where, at the end of the first 5-day period, the seed-piece roots which had developed from this node were cut off. At the time the photograph was taken no additional seed-piece roots had developed from the root primordia held in reserve.

The record of this particular node shows that at the end of the second 5-day period 96 of its 127 root primordia had developed into roots but that, after shoot roots began to develop from the bud of this node, even after eight additional 5-day periods in the ground, only four more root primordia of this node developed into roots.

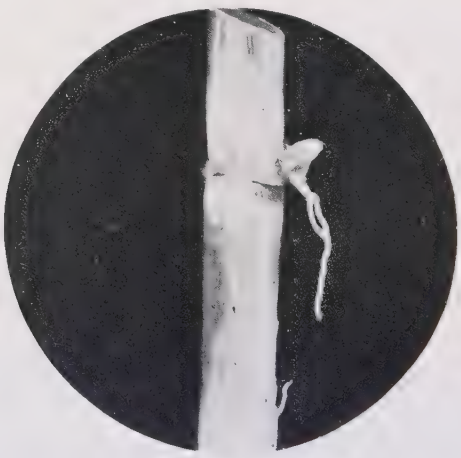

Fig. 11. Showing a seed piece of the variety P. O. J. 36, the buds of which had put out shoot roots by the end of the second 5-day period in the ground (Group I).

After the first 5-day period in the ground the buds of the seed pieces of Group I showed this condition with increasing frequency. This demonstrates how early the young cane plant (developing bud) may begin its own independent existence, which is practically complete at about the fourth month.* There is no doubt, however, that this character varies with the variety and is greatly influenced by temperature and moisture. In Figs. 1 to 4 can be seen how these shoot roots developed on other groups.

Counts were made of the number of shoot roots developing from shoots on the several groups of seed pieces as they were taken out of the ground at the various intervals. These are shown in Table IV.

* Lee and Weller, Op. cit.

TABLE IV

Showing the total number of shoot roots developing from shoots on the group of seed pieces left undisturbed in the ground for 50 days and on the groups disturbed at intervals of 5, 10, 15, and 25 days. The figures (in parentheses) opposite these numbers followed by plus or minus signs indicate how much these totals were above or below the average for the disturbed seed pieces.

VARIETY	UNDISTURBED 50-Day Interval	DISTURBED				Average for Disturbed
		5-Day Intervals	10-Day Intervals	15-Day Intervals	25-Day Intervals	
H 109	86 (28.3+)	24 (33.7—)	59 (1.3+)	61 (3.3+)	87 (29.3+)	57.7
Lahaina	240 (114.8+)	72 (53.2—)	135 (9.8+)	138 (12.8+)	129 (3.8+)	125.2
Yellow Caledonia	329 (138.8+)	247 (56.8+)	133 (57.2—)	186 (4.2—)	195 (4.8+)	190.2
D 1135	234 (12.0+)	193 (29.0—)	307 (85.0+)	212 (10.0—)	176 (46.0—)	222.0
Uba	627 (206.5+)	309 (111.5—)	391 (29.5—)	396 (24.5—)	596 (175.5+)	420.5
P. O. J. 213	626 (312.8+)	187 (126.2—)	292 (21.2—)	393 (79.8+)	381 (67.8+)	313.2
P. O. J. 36	643.3 (381.4+)	341.3 (20.6—)	298.1 (63.8—)	426.6 (64.7+)	381.6 (19.7+)	361.9

From the data of Table IV it is seen that when the seed peices of the variety H 109 were taken out, the developing roots cut off, and replanted at intervals of 5, 10, 15 and 25 days the number of shoot roots averaged 57.7 for these four groups. Those left undisturbed in the ground for 50 days developed 86 shoot roots, or 28.3 more for the undisturbed than for the *average* of the disturbed. On the seed pieces of Yellow Caledonia undisturbed for 50 days 329 shoot roots developed, or 138.8 more than the average for the disturbed seed pieces. From these data it is seen that for every variety examined the number of shoot roots developing on shoots from seed pieces undisturbed for 50 days *exceeded* the average of those developing on shoots from seed pieces disturbed at intervals of 5, 10, 15 and 25 days for 50 days. This is in contrast with the data of Table III, where, without exception, for the same varieties the percentage of seed-piece roots developing on seed pieces undisturbed for 50 days *was less* than the average of those developing on seed pieces disturbed at intervals of 5, 10, 15 and 25 days for 50 days.

As was mentioned above, these facts may well find practical application in the practice of off-barring and sub-soiling. As was shown by the contrasted data of Tables III and IV *the "pruning" of the seed-piece roots stimulated into development root primordia of the seed pieces which under normal conditions would have been held in reserve. The "pruning" of the shoot roots resulted only in fewer roots being developed from these shoots.* Inasmuch as the cane plant (developing shoot) ultimately relies upon its own shoot roots, the "pruning" of these shoot roots can result in only seriously handicapping its normal development.

The relationship which exists between old ratoon roots and the roots developing from the new ratoon shoots would be expected to be similar to that of the functioning seed-piece roots to the developing shoot roots of the plant crop.*

Off-barring and sub-soiling, therefore, which are done early enough to avoid cutting off roots from the shoots and to so cut away the old root mass as to make water, fertilizer, and air more easily available to the developing shoot roots should result only in benefit. Off-barring and sub-soiling which is done so late as to injure developing shoot roots can result only in harm.

Summary

1. A study was made of the development of the roots of the sugar cane plant from the root primordia, which occur as "root dots" on the "root bands" (Keimring) at the base of the internodes of the stems.

2. The number of root primordia and, therefore, the possible number of seed-piece roots per node differed greatly for the varieties studied.

3. Fifty cuttings of the variety H 109 were divided into 5 groups of 10 cuttings each and planted in the ground for 50 days. The 10 cuttings of Group I were removed from the soil every 5 days, and after the number of seed-piece roots developing on them had been recorded and cut off, they were replanted. The 10

* An experiment now in progress to determine this relationship between ratoon roots and roots from the ratoon shoots seems to confirm this statement.

cuttings of Group II were treated in the same manner as were those of Group I at intervals of 10 days, those of Group III were treated in the same way at intervals of 15 days, those of Group IV at intervals of 25 days, and those of Group V at the end of one period of 50 days. The number of shoot roots produced by the developing shoots was also recorded. Irrigations were given every fifth day at the rate of one inch per acre and were so timed as to be given immediately after each group was replanted. The varieties Lahaina, Yellow Caledonia, D 1135, Uba, P. O. J. 213 and P. O. J. 36 were also studied.

4. The number and per cent of the root primordia developing into seed-piece roots at different periods of time were determined. At the end of the first 5-day period, for example, on the ten H 109 seed pieces of Group I, 139 root primordia, or 3.6 per cent of the total, had developed into seed-piece roots, while on the Yellow Caledonia of the same group 2871, or 64.6 per cent, had developed.

5. The percentage of root primordia developing into seed-piece roots on seed pieces planted for 50 days is very little higher, if any, than for seed pieces planted for from 5 to 25 days.

6. A certain number of root primordia are held in reserve and develop only in case of need. The total per cent of root primordia developing into seed-piece roots was less for seed pieces left in the ground undisturbed for 50 days than for seed pieces disturbed at intervals of 5, 10, 15 and 25 days for the same period.

7. No correlation existed between the number of root primordia of different varieties and the development of the shoots from the buds, which does not preclude, however, a correlation between development of shoot ("stand of cane") and the number of root primordia for a given variety.

8. Shoot roots developed from the root primordia of the bud and pushed out between the bud scales as early as 5 days after the seed pieces were planted.

9. For the varieties studied the number of shoot roots developing on shoots from seed pieces undisturbed for 50 days *exceeded* the average of the number developing on shoots from seed pieces disturbed at intervals of 5, 10, 15 and 25 days. This is in contrast with the data for the seed-piece roots for, without exception for the same varieties, the percentage of seed-piece roots developing on seed pieces undisturbed for 50 days *was less* than the average of those developing on seed pieces disturbed at intervals of 5, 10, 15 and 25 days.

10. These facts may help interpret the significance of various types of root injury and may have a practical application to the practice of off-barring and subsoiling. The "pruning" of the seed-piece roots stimulated into development root primordia of the seed pieces which under normal conditions would have been held in reserve. The "pruning" of the shoot roots resulted in fewer roots being developed from the shoots.

Relative Resistance and Susceptibility of Hawaiian and Introduced Cane Varieties to Eye Spot and Brown Stripe Diseases

By C. C. Barnum

Part I

Varieties in Relation to Eye Spot Disease

This paper presents all the data that have become available on the subject of inherent eye spot resistance, to the present date. A paper on "Field Observations on the Degree of Resistance and Susceptibility of Seedlings to Eye Spot," by Martin, which appeared in the *Planters' Record,* Vol. XXXII, No. 3, July, 1928, covered only the observations made by himself on canes then growing at Waialua Agricultural Company, Ltd., under eye spot conditions. In this paper, Martin suggested and adopted the plan of using an index sign to indicate the relative resistance or susceptibility to eye spot disease of cane under test.

In the present paper, the observations of all observers are taken into account and the index sign here given is a composite of all records available for each particular cane under observation. The number of observations considered for each seedling is recorded in each instance and the average index sign is determined from a careful weighing of all the recorded observations. Resistance to eye spot disease is indicated by the plus sign, +; extreme resistance by the use of two plus signs, ++; equal susceptibility with that of H 109, as a standard in all cases, is indicated with the equality sign, =; while greater susceptibility to the disease than is exhibited by adjacent lines of similar-aged H 109 cane, is indicated by one or more minus signs, —, ——. Where only one observation for a single variety is recorded too much reliance must not be placed on the index sign here recorded. The canes which have been under field test for agricultural qualities over a relatively long period of time have a larger number of observations recorded herewith than have the more recently developed or introduced canes.

Observations have been made on canes in eye spot areas on both Oahu and Kauai, as well as a few observations on Maui and Hawaii. The observations of R. Bryan, H. K. Stender, R. H. McLennan, J. P. Langley, J. A. Verret, C. G. Lennox, A. J. Mangelsdorf, R. Conant, G. F. Fisher, J. P. Martin, and the writer have all been condensed to form this listing of the canes.

The canes have been grouped in order of their importance and of their propagation; the miscellaneous plantation-propagated canes have been arranged in an alphabetical sequence. The main groups appear in the following sequence:

1. Introduced canes.
2. Standard canes.
3. Alphabet varieties, Oahu propagation 1916-1920.
4. H varieties; H 146 to H 3001.

5. 1917 O. P., 20-S, 1924 O. P. varieties.
6. Manoa varieties, beginning with 1922 propagation.
7. H 5900 varieties.
8. H 7000, H 8100 and H 8600 varieties.
9. H 8900 varieties.
10. H 9800 and H 9900 varieties.
11. U. H. and U. D. varieties.
12. 25-C varieties.
13. 26-C varieties.
14. 27-C varieties.
15. 25-Q varieties.
16. Ewa varieties.
17. Waialua varieties.
18. Wailuku varieties.
19. Miscellaneous varieties.

From time to time observations have been made of the occurrence of mosaic disease on the canes under observation. In this report all varieties on which definite cases of mosaic have been observed are identified by means of an asterisk which precedes the name of the listed variety.

The position of the ×, opposite each variety under either Group I, II, III, or IV, in one of the four columns on the right-hand side of the table, designates the value of the cane variety in relation to eye spot disease. Only those canes for which an × appears in either Group 1 or II are sufficiently resistant for propagation in eye spot areas. Those canes falling in Group III or IV are entirely too susceptible for planting in eye spot areas.

No consideration has been given in this paper to the agricultural qualities of any of the canes listed. The list of cane varieties in relation to eye spot disease is presented in the following table:

			Resistant		Susceptible	
	Index Sign	Number of Observations	Group I Highly Resistant	Group II Moderately Resistant	Group III Equal to H 109	Group IV Highly Susceptible
1. Introduced Canes:						
P. O. J. 36	+	11		×		
" 36M	+	2		×		
" 213	+ +	10	×			
" 228	+	4		×		
" 234	+ +	7	×			
" 826	+	4		×		
" 979	+ +	10		×		
" 2221	+	2		×		
" 2379	+	4		×		
" 2714	+	5		×		
" 2725	+	2		×		
" 2727	+	5		×		
S. W. 3	=	3			×	
D. I. 52	+	5		×		

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
2. Standard Canes:						
D 1135	+	3		×		
Yellow Caledonia	++	5	×			
Yellow Tip	+	5		×		
Uba	+	1		×		
Striped Mexican	+	2		×		
Badila	++	2	×			
3. Alphabet Varieties:						
AA3	=	2			×	
AA4	—	1				×
AA5	——	2				×
AA6	++	2	×			
AA7	+	2		×		
ABA	—	2				×
ABB	=	2			×	
ABC	=	2			×	
ABD	+	2		×		
ABE	=	2			×	
ABF	+	1		×		
ABG	+	1		×		
ABH	+	2		×		
ABI	=	2			×	
ABJ	=	2			×	
ABK	=	1			×	
ABL	—	1				×
ABM	—	1				×
ABN	—	1				×
ABO	—	2				×
ABP	—	1				×
PMB	+	1		×		
4. H Varieties; H 146 to H 3001:						
H 146	+	1		×		
H 333	——	1				×
H 389	+	1		×		
H 411	——	1				×
H 427	——	1				×
H 455	+	1		×		
* H 456	+	11		×		
H 460	+	1		×		
H 463	+	1		×		
H 471	—	3				×
H 3001	=	3			+	
5. 1917 O. P., 20-S, and 1924 O. P. Varieties:						
1917 O. P. 36	—	1				×
1917 O. P. 299	++	1	×			
1917 O. P. 384	=	1			×	

* Asterisk preceding the name of any variety indicates the observation of mosaic disease on such canes.

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
1917 O. P. 389	—	1				×
1917 O. P. 395	+ +	1	×			
1917 O. P. 719	=	1			×	
20-S-16	+ +	4	×			
20-S-17	+ +	1	×			
20-S-18	+	2		×		
* 20-S-19	=	4			×	
1924 O. P. 83	=	2			×	
1924 H 3	+	1		×		
1924 H 129	+	1		×		
1924 L 4	+	1		×		
6. Manoa Varieties:						
Manoa 36	=	2			×	
* " 127	+	2		×		
* " 160	+	1		×		
" 198	+ +	1	×			
" 213	=	1			×	
" 300	+	1		×		
" 301	+	3		×		
" 302	+ +	1	×			
" 303	+ +	2	×			
" 304	+ +	2	×			
" 305	+ +	1	×			
" 306	+	1		×		
" 309	+	1		×		
" 311	+	1		×		
7. H 5900 Varieties:						
H 5908	— —	2				×
H 5909	+ +	9	×			
* H 5919	+ +	5	×			
H 5922	=	1			×	
H 5923	+	1		×		
H 5940	—	1				×
* H 5946	+	3		×		
H 5949	+	3		×		
* H 5965	+	1		×		
H 5972	=	2			×	
H 5974	+	1		×		
H 5978	+	2		×		
H 5986	=	3			×	
8. H 7000, H 8100 and H 8600 Varieties:						
H 7101	+	3		×		
H 7102	—	3				×
H 76719	+	5		×		
H 7860	=	2			×	
H 7878	=	2			×	

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
H 8136	— —	3				×
* H 8139	— —	4				×
H 8158	—	3				×
H 81360	+	10		×		
H 86143	+ +	4	×			
H 86374	=	3			×	
H 86441	—	4				×
* H 86465	+ +	6	×			
H 86472	+ +	6	×			
H 86484	+	10		×		
H 86485	+	1		×		
9. H 8900 Varieties:						
H 8901	=	3			×	
H 8906	=	4			×	
H 8907	+ +	2	×			
H 8911	=	2			×	
H 8918	=	2			×	
H 8919	=	2			×	
H 8920	+	1		+		
H 8922	—	2			×	
H 8924	--	1				×
H 8929	+	1		×		
H 8933	=	2			×	
H 8935	—	3				×
H 8938	—	1				×
H 8939	+ +	1	×			
H 8940	=	2			×	
H 8942	+	6		×		
H 8945	+	2		×		
H 8946	—	1				×
H 8947	=	2			×	
H 8948	+	2		×		
H 8949	— —	2				×
H 8952	+ +	9	×			
H 8954	=	5			×	
H 8956	—	1				×
H 8958	=	5			×	
H 8961	+ +	8	×			
* H 8965	+	16		×		
H 8968	—	1				×
H 8969	+	7		×		
H 8973	—	2				×
H 8976	=	1			×	
H 8978	=	4			×	
H 8982	=	1			×	
H 8983	—	3				×
H 8984	=	3			×	

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
* H 8988	+	8		×		
H 8992	— —	2				×
H 8993	+ +	8	×			
H 8994	+ +	14	×			
H 8998	+	3		×		
H 89102	+	8		×		
H 89291	— —	5				×
H 89296	—	2				×
H 89321	+ +	2	×			
10. H 9800 and H 9900 Varieties:						
H 9801	+	1		×		
H 9802	+	1		×		
H 9803	+	1		×		
H 9804	+	1		×		
H 9805	+	1		×		
H 9806	+	4		×		
H 9807	+	1		×		
H 9808	+ +	1	×			
H 9809	+	2		×		
H 9810	+	2		×		
H 9811	+ +	4	×			
* H 9872	+	3		×		
H 9813	+	1		×		
H 9904	=	2			×	
H 9910	+	1		×		
H 9913	+	1		×		
H 9923	+	2		×		
H 9924	+	1		×		
H 9929	+	1		×		
11. U. H. and U. D. Varieties:						
U. H. 1	+ +	3	×			
U. H. 2	+ +	1	×			
U. H. 3	+ +	1	×			
U. H. 4	+ +	1	×			
U. D. 1	+	11		×		
U. D. 4	+ +	1	×			
U. D. 6	+ +	1	×			
U. D. 7	+ +	1	×			
U. D. 23	+ +	1	×			
U. D. 35	+ +	1	×			
U. D. 39	+ +	2	×			
U. D. 42	+ +	1	×			
U. D. 58	+ +	3	×			
U. D. 62	+ +	3	×			
U. D. 65	+	3		×		

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
U. D. 66	++	1	×			
U. D. 75	++	3	×			
U. D. 79	++	1	×			
U. D. 88	++	1	×			
U. D. 92	++	1	×			
U. D. 100	++	2	×			
U. D. 104	++	1	×			
U. D. 106	++	1	×			
U. D. 110	++	1	×			
12. 25-C Varieties:						
25-C-1	+	5		×		
25-C-2	+	3		×		
25-C-3	+	3		×		
* 25-C-4	+	8		×		
25-C-5	=	3			×	
25-C-6	+	3		×		
25-C-7	+	7		×		
25-C-8	+	4		×		
25-C-9	−	5				×
25-C-10	−−	4				×
25-C-11	=	3			×	
25-C-12	+	3		×		
25-C-13	−	3				×
* 25-C-14	+	3		×		
25-C-15	+	3		×		
25-C-16	+	7		×		
25-C-17	−	4				×
25-C-18	−−	3				×
25-C-19	−	5				×
25-C-20	−−	4				×
25-C-21	=	4			×	
25-C-22	=	3			×	
25-C-24	+	3		×		
25-C-25	=	2			×	
25-C-26	−−	3				×
25-C-27	−−	3				×
* 25-C-28	=	4			×	
25-C-29	−	2				×
25-C-30	+	3		×		
25-C-31	++	4	×			
25-C-32	+	3		×		
25-C-33	−	2				×
25-C-34	++	6	×			
25-C-35	=	3			×	
25-C-36	−	2				×
25-C-37	+	2		×		
25-C-38	+	4		×		

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
25-C-39	+	2		×		
25-C-40	=	2			×	
25-C-41	+	3		×		
25-C-42	+	3		×		
25-C-43	—	2				×
25-C-44	—	2				×
25-C-45	— —	2				×
25-C-46	+	3		×		
25-C-47	=	2			×	
13. 26-C Varieties:						
26-C-48	+ +	4	×			
26-C-52	=	5			×	
26-C-53	=	1			×	
26-C-55	—	2				×
26-C-58	+	1		×		
26-C-61	+	2		×		
26-C-63	+	2		×		
26-C-71	+	5		×		
26-C-80	+	1		×		
26-C-95	— —	1				×
26-C-110	=	1			×	
26-C-112	+	2		×		
26-C-113	+ +	3	×			
26-C-116	=	3			×	
26-C-118	+	2		×		
26-C-122	+ +	2	×			
26-C-137	—	1				×
26-C-141	+	1		×		
26-C-143	=	1			×	
26-C-144	—	1				×
26-C-148	+ +	4	×			
26-C-149	=	1			×	
26-C-152	+	1		×		
26-C-157	— —	1				×
26-C-163	=	3			×	
26-C-165	+	1		×		
26-C-169	=	1			×	
26-C-176	=	1			×	
26-C-177	=	2			×	
26-C-182	+	3		×		
26-C-188	+	2		×		
26-C-189	+	4		×		
26-C-191	=	1			×	
26-C-193	=	1			×	
26-C-194	—	2				×
26-C-196	=	1			×	
26-C-199	—	1				×

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
26-C-204	— —	2				×
26-C-211	+ +	1	×			
26-C-213	—	1				×
26-C-216	—	3				×
26-C-219	—	2				×
26-C-222	—	1				×
26-C-226	— —	1				×
26-C-228	— —	1				×
26-C-235	— —	1				×
26-C-237	— —	1				×
26-C-240	— —	1				×
26-C-241	—	2				×
26-C-245	=	2			×	
26-C-249	=	2			×	
26-C-250	+	3		×		
26-C-254	+	1		×		
26-C-256	+ +	1	×			
26-C-259	=	1			×	
26-C-261	—	2				×
26-C-263	+ +	2	×			
26-C-264	=	1			×	
26-C-266	+ +	1	×			
26-C-267	+ +	1	×			
26-C-268	+ +	4	×			
26-C-270	+	1		×		
26-C-274	+	2		×		
26-C-277	=	1			×	
26-C-292	— —	1				×
14. 27-C Varieties:						
27-C-289	+ +	1	×			
27-C-340	+ +	1	×			
27-C-346	+	1		×		
27-C-372	+ +	1	×			
27-C-376	+	1		×		
27-C-378	+ +	1	×			
27-C-445	+	2		×		
27-C-452	+	1		×		
27-C-453	+	1		×		
27-C-483	+ +	1	×			
27-C-485	+	1		×		
27-C-548	+	1		×		
27-C-549	+	1		×		
27-C-556	+	1		×		
27-C-557	+	1		×		
15. 25-Q Varieties:						
25-Q-1	+	1		×		
25-Q-11	+ +	1	×			

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
25-Q-18	+ +	1	×			
25-Q-25	+	1		×		
25-Q-70	+ +	1	×			
25-Q-73	+ +	1	×			
25-Q-79	+ +	1	×			
25-Q-110	+ +	1	×			
25-Q-119	+	1		×		
25-Q-126	+	1		×		
25-Q-156	+ +	1	×			
25-Q-214	+ +	1	×			
25-Q-224	+ +	1	×			
16. Ewa Varieties:						
Ewa 177	+	2		×		
* " 199	— — —	4				×
" 325	+	1		×		
* " 371	+	1		×		
" 533	+ +	4	×			
* " 555	+	3		×		
" 566	+ +	1	×			
" 569	+ +	3	×			
" 570	+ +	4	×			
" 580	— —	1				×
* " 607	—	3				×
" 608	+	3		×		
* " 609	+	3		×		
* " 610	=	3			×	
* " 611	+	4		×		
* " 612	=	3			×	
* " 613	=	3			×	
" 614	=	3			×	
* " 615	=	3			×	
* " 616	+ +	4	×			
* " 617	=	3			×	
* " 618	+	3		×		
* " 619	+	3		×		
* " 620	+ +	3	×			
* " 621	+	3		×		
* " 622	=	3			×	
* " 623	—	3				×
* " 624	—	3				×
* " 625	— —	4				×
* " 626	=	4			×	
* " 627	=	3			×	
" 628	+	3		×		
* " 629	— —	3				×
* " 630	—	3				×
" 631	—	3				×

	Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
Ewa 639	=	1			×	
" " 800	=	5			×	
" 801	+	5		×		
" 802	=	3			×	
" 803	—	3				×
" 804	+	3		×		
17. Waialua Varieties:						
Waialua 1	+ +	5	×			
" 2	+	3		×		
" 3	+	3	×			
" 4	+	5		×		
" 5	=	2			×	
" 6	+	3	×			
" 7	=	2			×	
" 8	+	5		×		
" 9	+	3	×			
" 10	+	1		×		
" 11	+	1		×		
" 13	+ +	1	×			
" 14	+	1	×			
" 15	+ +	1	×			
" 16	+	1	×			
" 17	+ +	1	×			
" 18	+ +	1	×			
" 19	=	1			×	
" 20	+	1		×		
" 21	+ +	1	×			
" 22	+	1	×			
" 23	+	1		×		
" 24	=	1			×	
" 25	+ +	1	×			
" 26	=	1			×	
" 27	+	1		×		
" 28	+ +	1	×			
" 29	+	1		×		
" 30	+	1		×		
" 31	+ +	1	×			
" 32	+	1		×		
" 33	+	1		×		
" 34	+	1		×		
" 35	+	1		×		
" 36	+ +	1	×			
" 37	+	1		×		
" 38	+	1		×		
" 39	+	1		×		
" 40	+	1		×		
" 41	+	1		×		

				Resistant		Susceptible	
		Index Sign	Number of Observations	Group I Highly Resistant	Group II Moderately Resistant	Group III Equal to H 109	Group IV Highly Susceptible
Waialua	42	+	1		×		
"	43	+	1		×		
"	44	+ +	1	×			
"	45	+	1		×		
"	46	+	1		×		
"	47	+	1		×		
"	48	=	1			×	
"	49	+	1		×		
"	50	+	1		×		
"	51	+ +	1	×			
"	52	+ +	1	×			
"	53	+	1		×		
"	54	=	1			×	
"	55	=	1			×	
"	56	=	1			×	
"	57	+	1		×		
"	58	+	1		×		
"	59	+	1		×		
"	60	+	1		×		
"	61	+	1		×		
"	62	+	1		×		
"	63	=	1			×	
"	64	+	1		×		
"	65	+	1		×		
"	66	+	1		×		
"	67	+	1		×		
"	68	+	1		×		
"	69	−	1				×
"	70	+	1		×		
"	71	+	1		×		
"	72	+ +	1	×			
"	73	+	1		×		
"	74	+	1		×		
"	75	+	1		×		
"	76	+	1		×		
"	77	=	1			×	
"	78	+	1		×		
"	79	+	1		×		
"	80	+	1		×		
"	81	+	1		×		
"	82	+	1		×		
"	83	−	1				×
"	84	+	1		×		
"	85	+	1		×		
"	86	+	1		×		
"	87	+	1		×		
"	88	=	1			×	
"	89	+	1		×		

		Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
Waialua	90	+	1		×		
"	91	+	1		×		
"	92	+	1		×		
"	93	+	1		×		
"	94	+	1		×		
"	95	+	1		×		
"	96	+	1		×		
"	97	+	1		×		
"	98	+	1		×		
"	99	+	1		×		
"	100	+	1		×		
"	101	+	1		×		
"	102	+	1		×		
"	103	=	1			×	
"	105	+	1		×		
"	106	+	1		×		
"	107	+	1		×		
"	108	+	1		×		
"	110	+	1		×		
"	111	+	1		×		
"	112	+	1		×		
"	115	+	1		×		
"	116	+	1		×		
"	117	=	1			×	
"	119	+	1		×		
"	120	+	1		×		
"	121	+	1		×		
"	122	+	1		×		
"	123	+	1		×		
"	124	+	1		×		
"	125	+	1		×		
"	126	+	1		×		
"	127	+	1		×		
"	128	+	1		×		
"	129	+	1		×		
"	130	+	1		×		
"	131	+	1		×		
"	132	+	1		×		
18. Wailuku Varieties:							
* Wailuku	1	+	7		×		
"	2	+	6		×		
"	3	+	2		×		
* "	4	=	6			×	
"	5	=	2			×	
"	6	=	2			×	
"	8	—	1				×
"	9	=	1			×	

			Index Sign	Number of Observations	Resistant: Group I Highly Resistant	Resistant: Group II Moderately Resistant	Susceptible: Group III Equal to H 109	Susceptible: Group IV Highly Susceptible
	Wailuku	10	+	4		×		
	"	11	+	11		×		
	"	12	+	2		×		
	"	13	=	2			×	
	"	17	—	1				×
	"	29	=	1			×	
	"	30	+	1		×		
	"	47	+	1		×		
	"	48	+	2		×		
	"	51	+	7		×		
	"	53	+	1		×		
	"	63	+	1		×		
	"	66	+ +	1	×			
*	"	73	+ +	3	×			
	"	60701	=	1			×	
19.	Miscellaneous Varieties:							
	Grove Farm	84	=	3			×	
	Honokaa	1	+	4		×		
	Honomu	5	+	1		×		
	"	7	=	1			×	
	"	9	+	2		×		
	"	16	+	1		×		
	"	27	+	1		×		
	Kekaha	3	=	1			×	
	"	25-3	+ +	1	×			
	"	25-8	=	1			×	
	"	25-9	—	1				×
	"	26-12	—	1				×
	"	26-13	=	1			×	
	"	456	+	5		×		
	Kilauea	2	+	2		×		
	Kohala	73	+	6		×		
	"	105	+	2		×		
*	"	107	+	3		×		
	"	115	+ +	2	×			
*	"	202	+	10		×		
	Koloa	X2	+	3		×		
	"	X8	+	1		×		
	Lihue Plantation Varieties:							
	L. P.	9	+	1		×		
	L. P.	14	+ +	1	×			
	L. P.	25	=	1			×	
	L. P.	27	+	1		×		
	L. P.	34	+	1		×		

			Resistant		Susceptible	
	Index Sign	Number of Observations	Group I Highly Resistant	Group II Moderately Resistant	Group III Equal to H 109	Group IV Highly Susceptible
L. P. 36	—	1				×
L. P. 38	+	1		×		
L. P. 40	+	1		×		
L. P. 49	—	1				×
L. P. 60	+	1		×		
L. P. 65	+	1		×		
L. P. 91	+	1		×		
Makee Varieties:						
Kealia 1 (K. M. 1)	=	2			×	
K. M. 1-5	—	1				×
K. M. 1-7	—	1				×
K. M. 1-13	—	1				×
K. M. 2-1	—	1				×
K. M. 2-3	—	1				×
K. M. 2-8	=	1			×	
K. M. 2-10	+	1		×		
K. M. 4-3	=	1			×	
K. M. 4-10	—	1				×
Makaweli Varieties:						
Mak. 1	=	1			×	
" 3	+	5		×		
" 309		0				
" 476	=	1			×	
McBryde Varieties:						
McB. "H"	—	2				×
" 1	—	2				×
" 3	=	2			×	
" 4	+	2		×		
* " 5	—	4				×
* " 6	+	2		×		
" 7	=	1			×	
" 8	+	2		×		
Waimanalo Varieties:						
Nalo 13	=	2			×	
" 31	+	5		×		
" 44	+	5		×		
Onomea H 109	=	1			×	
Onomea 2	+	1		×		
Paia F	+	4		×		
" D	=	1			×	
" 71	—	2				×
" 75	=	1			×	
" 150	=	3			×	

		Resistant		Susceptible	
	Index Sign / Number of Observations	Group I Highly Resistant	Group II Moderately Resistant	Group III Equal to H 109	Group IV × Highly Susceptible
Paia 163	— 2				
" 180	+ 5		×		
" 186	+ 5		×		
Paauhau 1	+ 1		×		
Puunene 230	+ + 1	×			
Waipio 7	+ 4		×		
" 8	+ 4		×		
" 152	+ 1		×		
Waipahu 30	+ + 1	×			
" 31	+ 1		×		
" 35	+ 1		×		
" 36	+ + 1	×			
" 51	+ + 1	×			
" 81	+ + 1	×			
" 89	+ + 1	×			
" 97	+ 2		×		
" 129	+ 2		×		
" 137	+ 1		×		
" 152	+ 1		×		

Part II

Cane Varieties in Relation to Brown Stripe Disease

The earliest extensive publication on brown stripe is the work of Faris (1) in which he differentiates between three *Helminthosporium* leaf diseases of sugar cane in Cuba. In this paper he points out the differences between eye spot and brown stripe diseases. Drechsler (2) reported at the meeting of the American Phytopathological Society at Nashville, Tennessee, the occurrence of brown stripe in Cuba, Georgia and Florida and provisionally named the causal organism, *Helminthosporium stenospilum* n. sp. Martin and Agee (3) in October, 1928, pointed out the resemblance of the leaf disease appearing at Waialua Agricultural Company, to the disease designated by Faris and Drechsler as brown stripe disease of sugar cane. Cultural work on the organism has been conducted by Martin, and the organism isolated from typical brown stripe lesions on H 109 leaves collected at Waialua agreed with the description of *H. stenospilum* Drechsler.

It has been observed that many of those varieties which have shown definite resistance to eye spot disease have suffered considerably from attacks of brown stripe disease. There is some evidence to show that field conditions which make for poor cane growth favor brown stripe infection. Germination of the spores

and subsequent leaf infection is, however, dependent upon the presence of adequate moisture on the leaf surfaces. As Faris (1) points out in his work, "Brown stripe becomes destructive during periods of dry weather when the vitality of the cane is lowered . . ." The most severe outbreaks of brown stripe disease in Hawaii, have usually occurred on the less fertile fields and have been most noticeable during the drier summer and fall months. The severity of brown stripe disease on H 109 is being recognized in several areas. Further investigations of brown stripe disease are under way at this time.

The relative susceptibility of certain varieties to brown stripe disease has been observed and noted from time to time by members of the Station staff during the past year. The following list of canes has been arranged in much the same sequence as has been used in the listing of canes in relation to their resistance and susceptibility to eye spot disease. The list does not include as many canes as are tabulated in Part I of this paper, and includes only those canes on which several observations have been made. The list follows:

INTRODUCED AND STANDARD CANES

P. O. J. 36	Slightly affected
P. O. J. 234	Severely affected
P. O. J. 826	" "
P. O. J. 979	" "
P. O. J. 2221	" "
P. O. J. 2714	Slightly affected
P. O. J. 2878	Severely affected
S. W. 3	" "
H 109	Moderately affected
D 1135	" "
Badila	Severely affected
Yellow Caledonia	" "
Yellow Tip	Slightly affected
Striped Tip	" "
Uba	Moderately affected

HAWAIIAN VARIETIES

H 146	Severely affected
H 5909	Slightly affected
H 5919	Severely affected
20-S-18	" "
20-S-19	" "
H 81360	" "
H 86374	" "
H 8952	" "
H 8954	" "
H 8961	Slightly affected
H 8965	Moderately affected
H 8988	Severely affected
H 8994	Slightly affected
H 9806	" "

Ewa 371	Severely affected
" 628	" "
Kohala 107	Slightly affected
" 202	" "
Manoa 198	" "
" 300	" "
Makaweli 3	" "
Paia F	" "
" 150	" "
" 186	Severely affected
Waialua 1	" "
" 4	Slightly affected
" 8	" "
Wailuku 11	Severely affected
" 12	Slightly affected
Waipahu 129	Severely affected
25-C-24	Slightly affected
25-C-31	Severely affected
27-C-306	" "
27-C-340	" "
27-C-372	" "
27-C-375	" "
27-C-391	" "
27-C-556	" "

LITERATURE CITED

(1) Faris, James A. 1928. Three Helminthosporium Diseases of Sugar Cane. Phytopathology, Vol. 18, pp. 753-774.

(2) Drechsler, Chas. 1928. A Species of Helminthosporium Distinct from Helminthosporium sacchari, Causing Brown Stripe of Sugar Cane. Phytopathology, Vol. 18, pp. 135-136.

(3) Director's Monthly Letter, October, 1928. Experiment Station, H. S. P. A.

Sugar Prices

96° Centrifugals for the Period

September 19, 1929, to December 13, 1929.

Date		Per Pound	Per Ton	Remarks
Sept.	19, 1929	3.96¢	$79.20	Porto Ricos.
"	20	3.96	79.20	Porto Ricos.
"	24	4.05	81.00	Porto Ricos, 4.02; Cubas, 4.08.
"	25	4.08	81.60	Cubas.
Oct.	8	4.05	81.00	Cubas.
"	21	4.02	80.40	Cubas.
"	28	3.89	77.80	Cubas.
"	29	3.83	76.60	Cubas.
Nov.	1	3.74	74.80	Philippines.
"	7	3.74	74.80	Philippines, 3.71; Cubas, 3.77.
"	12	3.71	74.20	Cubas.
"	16	3.77	75.40	Cubas.
"	19	3.71	74.20	Cubas.
"	22	3.77	75.40	Porto Ricos.
"	25	3.725	74.50	Cubas, 3.74, 3.71.
"	26	3.68	73.60	Cubas.
Dec.	2	3.74	74.80	Cubas.
"	3	3.71	74.20	Cubas.
"	10	3.74	74.80	Philippines.
"	11	3.77	75.40	Porto Ricos.
"	13	3.83	76.60	Philippines.